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INSTRUCTION MANUAL

EMR MODEL 229
TUNABLE DISCRIMINATOR
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Sarasota, Florida
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EMR MODEL 229 TUNABLE
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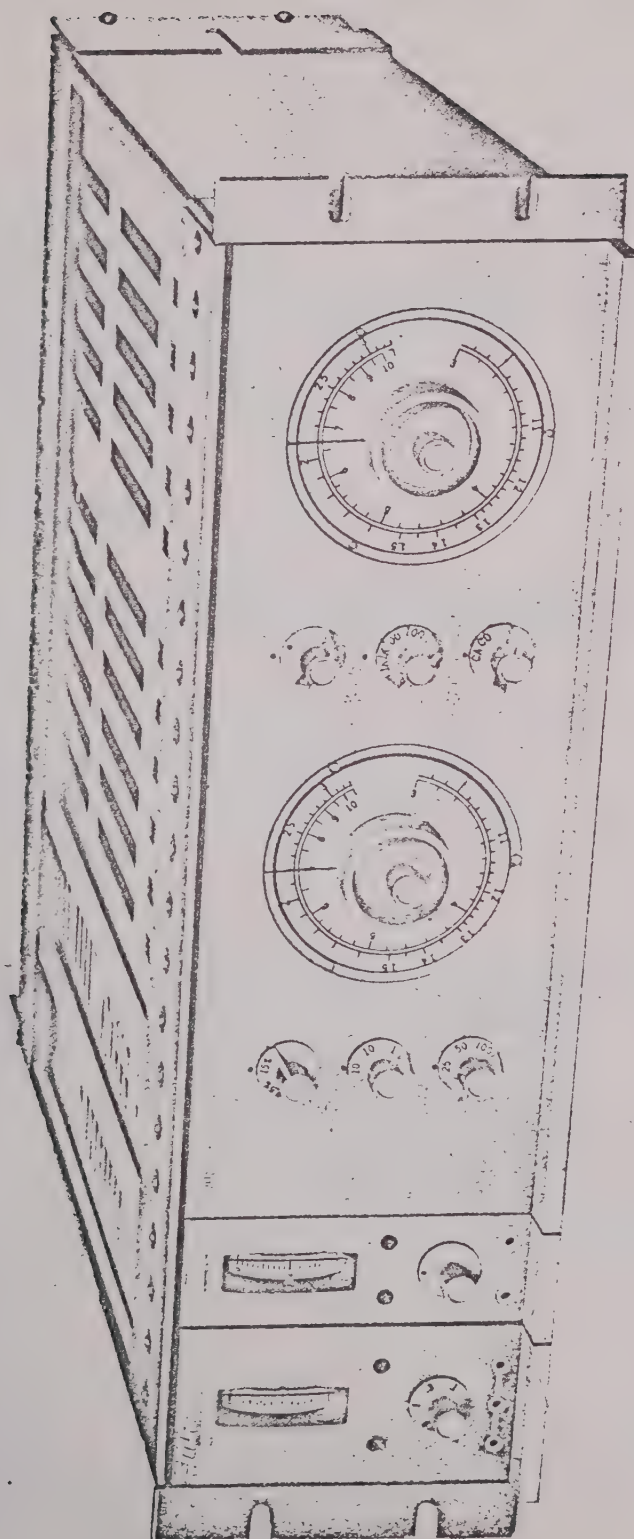
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EMR Model 229 Tunable Discriminator

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

This manual provides information describing operation, theory, and maintenance of the EMR Model 229 Tunable Discriminator. The discriminator is a precision instrument of all solid-state design for use in FM telemetry systems. Two models are available, providing a subcarrier center frequency tuning range of 100 CPS to 300 Kc. The Model 229A-01 covers the frequency range of 100 CPS to 100 Kc and the Model 229A-02 covers the frequency range of 300 CPS to 300 Kc. The input bandpass can be selected to accommodate subcarrier frequency deviations of $\pm 7.5\%$ or $\pm 15\%$.

1.2 FUNCTIONAL DESCRIPTION

The EMR Model 229 Tunable Discriminator employs a phase-locked-loop FM detector which provides improved signal-to-noise performance compared to other means of detection.

The FM multiplex from a receiver or magnetic-tape-reproduction system is applied to a tunable bandpass input filter of the discriminator. The discriminator can be tuned by front-panel controls to accept the desired subcarrier channel. Frequency deviations of $\pm 7.5\%$ or $\pm 15\%$ can also be selected by front-panel controls.

The input filter output is applied to a limiter which has sufficient gain to provide a constant-amplitude square-wave output to the FM detector throughout a 54-Db input signal range. A phase-locked-loop FM detector is employed for detection of the selected FM subcarrier. The phase-locked-loop detector consists of a phase detector, voltage-controlled oscillator (VCO), and loop amplifier and filter. As the subcarrier frequency varies in response to data modulation, the phase angle also varies. The phase detector senses this phase error and produces a proportionate output-voltage component. This output-voltage component changes at the same rate as the subcarrier signal frequency and the DC component is passed by a loop filter and applied as a controlling input to the VCO. The VCO changes in frequency and phase so as to bring the VCO output to the same frequency as that of the subcarrier signal.

Where data-signal characteristics are known, provision is made for adjustment of the loop-filter cutoff point. This adjusts the bandpass characteristics of the phase-locked loop in order to reject noise errors falling outside the loop bandwidth.

The detected signal is applied to the tunable low-pass output filter to remove components above the filter cutoff frequency. The signal is then fed to an output DC

amplifier. The output filter may be tuned to any cutoff frequency from 3 CPS to 30 Kc by an eight-step range switch and tuning control on the front panel. The low-pass output filter has an asymptotic slope of 18 Db per octave and can be switched by a front-panel control to permit operation as either a constant-amplitude or constant-delay filter.

The output DC amplifier is stabilized against drift by a solid-state, nonmechanical chopper operating at a chopping rate of 6 Kc. This system enables the discriminator to operate from power-source frequencies of 47 to 420 CPS without changing the chopper frequency and intelligence frequency.

At a predetermined input signal level, signal-loss circuitry illuminates a front-panel neon indicator lamp and clamps the discriminator output to ground. This protects output display devices such as recording galvanometers. The signal-loss threshold is adjustable, enabling the operator to set the level for optimum signal-to-noise performance.

1.3 PHYSICAL DESCRIPTION

The Model 229 Tunable Discriminator System is composed of four basic individual units as follows:

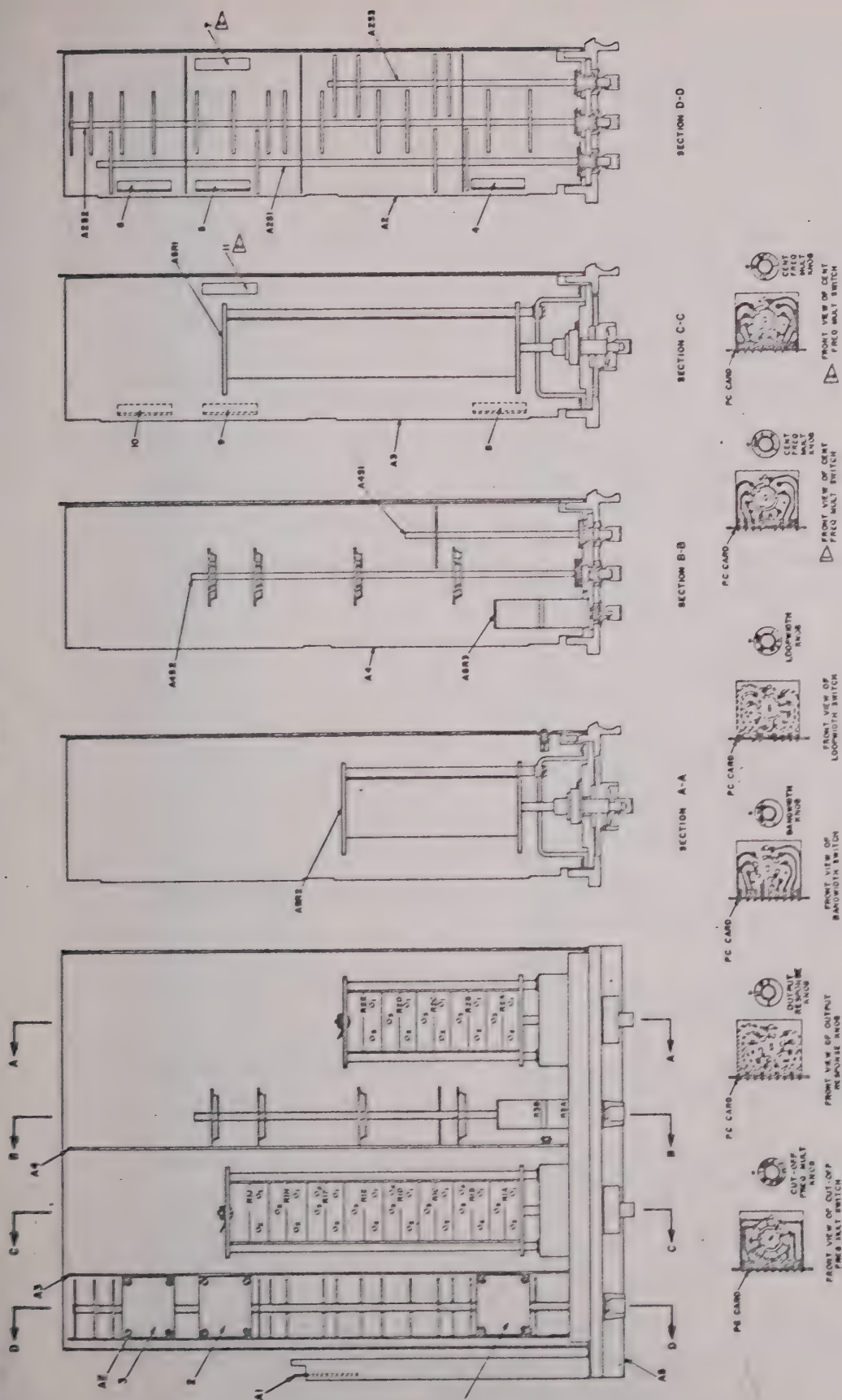
- a. Model 229A Tunable Channel Selector/Output Filter
- b. Model 210A Discriminator Chassis
- c. Model 223G Power Supply
- d. Model 222A Rack Adapter

The Models 229A, 210A, and 222A are covered in detail in this manual. Detailed information on the Model 223G Power Supply is available in a separate manual. The composite system occupies 5-1/4 inches of panel height in a standard 19-inch rack.

1.3.1 Model 229A Tunable Channel Selector/Output Filter (Figure 1-1)

Two versions of the Model 229A are available; designated as Model 229A-01 or Model 229A-02. The Model 229A-01 provides a frequency tuning range of 100 CPS to 100 Kc and the Model 229A-02 provides a frequency tuning range of 300 CPS to 300 Kc. The two models are identical in mechanical structure as described below.

Each of the four major subassemblies of the Model 229A is associated with an individual printed-circuit card as listed in Table 1-1. These cards provide the function of channel selection and output-filter response. Front-panel controls



NOTES:

1. USED ON MODEL 229A-01 ONLY.
2. USED ON MODEL 229A-02 ONLY.
3. EMR DRAWING CONTROL NO. 229-001.

Figure 1-1. Models 229A-01 and 229A-02 Tunable Channel Selector/Output Filter, Location of Subassemblies and Major Components

Table 1-1. Model 229A Tunable Channel Selector/Output Filter,
List of Subassemblies (Ref. Figure 1-1)

REF.	NAME	FUNCTION
A1	Plug card	Provides interconnections between 229A and 210A. Mates with 1J2 on 210A.
A2	Switching printed-circuit card	Contains the three switches listed below and all associated tuning components. 1. BANDWIDTH switch 2. CENT FREQ MULT switch 3. LOOP WIDTH switch
A3	Electronic printed circuit card	Contains the electronic circuits used in the bandpass input filter and loop filter.
A4	Output filter printed-circuit card	Contains the two switches listed below and all associated tuning components. 1. OUTPUT RESPONSE switch 2. CUTOFF FREQ MULT switch
A5	Front panel	Contains CENTER FREQUENCY KC and CUTOFF FREQUENCY CPS tuning controls and BALANCE potentiometer.
1	Interconnection card	Provides electrical connections between A2J1 and A3J1.
2	Interconnection card	Provides electrical connections between A2J2 and A3J2.
3	Interconnection card	Provides electrical connections between A2J3 and A3J3.
4	A2J1	Electrical connector jack for switching printed-circuit card.
5	A2J2	Electrical connector jack for switching printed-circuit card.
6	A2J3	Electrical connector jack for switching printed-circuit card.

Table 1-1 (Cont'd.). Model 229A Tunable Channel Selector/Output Filter,
List of Subassemblies (Ref. Figure 1-1)

REF.	NAME	FUNCTION
7	A2J4	Electrical connector jack for switching printed-circuit card (used on Model 229A-02 only).
8	A3J1	Electrical connector jack for electronic printed-circuit card.
9	A3J2	Electrical connector jack for electronic printed-circuit card.
10	A3J3	Electrical connector jack for electronic printed-circuit card.
11	A3J4	Electrical connector jack for electronic printed-circuit card (used on Model 229A-02 only).

are shaft connected to tuning components on the printed-circuit cards which, in turn, control center frequency and bandwidth.

Each subassembly is assigned a prefix letter and number for identification purposes. For example, A3R1 indicates resistor R1 on assembly A3 which is the electronic printed-circuit card.

1.3.2 Model 210A Discriminator Chassis

Four versions of the Model 210A Discriminator are available as follows:

- a. Model 210A-01--Standard model with negative-deviation polarity.
- b. Model 210A-02--Same as Model 210A-01 except for the addition of a nine-turn counter dial for bandedge-volts control.
- c. Model 210A-04--Same as Model 210A-01 except for addition of switchable deviation polarity.
- d. Model 210A-05--Same as Model 210A-01 except for addition of nine-turn counter dial for bandedge-volts control and switchable deviation polarity.

The Model 210A is a 1-5/8-inch modular chassis which mounts in the Model 222A Rack Adapter. The two major subassemblies are primarily composed of the main printed-circuit card and secondary printed-circuit card as shown in Figure 1-2 and listed in Table 1-2. The subassemblies are designated no. 1 and no. 2, respectively.

High temperature stability is obtained by using complementary pairs in the circuitry and enclosing all critical voltage-controlled-oscillator components within an oven assembly.

As shown in Table 1-2, each subassembly of the Model 210A is assigned a numerical prefix for identification of physical location. In addition, a circuit designation number is assigned to all Model 210A components to identify the circuit in which a component is used. The circuit-designation numbers are as follows:

100	Limiter
200	Phase detector and loop amplifier
300	Loss-of-signal and loss-of-lock
400	Voltage-controlled oscillator (VCO)
500	VCO oven controller

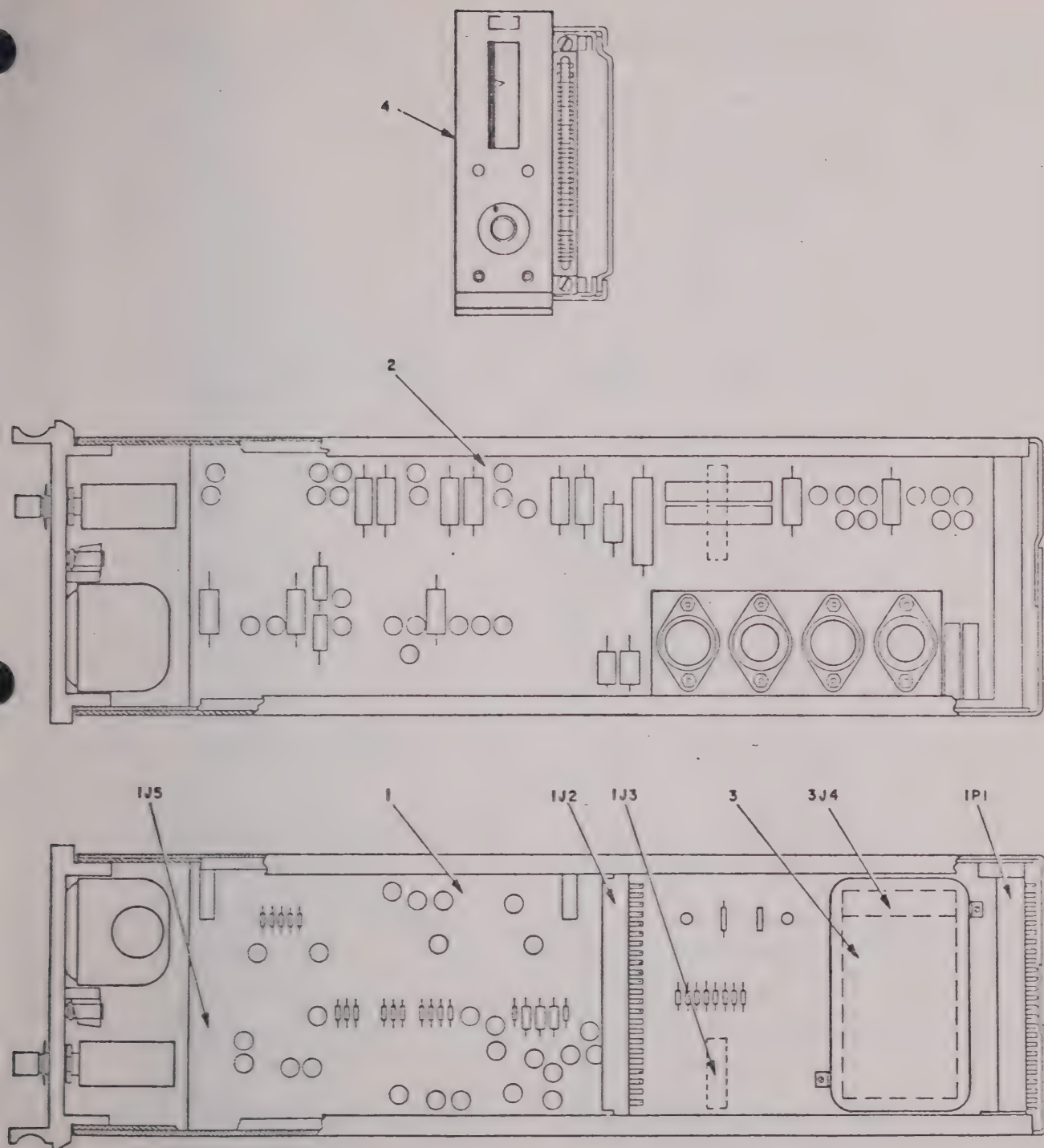


Figure 1-2. Model 210A Discriminator Chassis; Location of Subassemblies and Major Components

Table 1-2. Model 210A Discriminator Chassis,
List of Subassemblies and Major Components (Ref. Figure 1-2)

REF.	NAME	FUNCTION
1	Main printed-circuit card	Contains components of the following circuits: 1. Limiter 2. Phase detector and loop amplifier 3. VCO 4. Lock loss 5. Signal loss
2	Secondary printed-circuit card	Contains components of the following circuits: 1. Output amplifier 2. Chopper amplifier 3. Power regulators
3	Oven assembly	Contains components of oven temperature control circuit.
4	Front panel	Contains controls and indicators for operation of the Model 210A Discriminator Chassis.
1P1	Rear connector	Provides connections for power inputs and data output.
1J2	Channel selector/output filter connector	Provides connections between the Models 210A and 229A.
1J3	Main-to-secondary card connector	Provides connections between the main and secondary printed-circuit cards.
3J4	Oven connector	Provides all connections to oven controller unit.
1J5	Front-panel connector	Provides all connections to front-panel controls and indicators.

600	Output amplifier
700	Chopper amplifier
800	Power supply regulators
900	Inverting amplifier

Example: 1R119 indicates resistor R19 on assembly 1 (main printed-circuit card) which is part of the limiter circuit.

NOTE

The inverting amplifier is used only on Models 210A-04 and 210A-05 which contain a deviation-polarity control on the front panel.

1.3.3 Model 223G Power Supply

The Model 223G Power Supply has been designed specifically for use with the Model 229 system. Power can be supplied from two regulated and two unregulated output terminals. In addition, the power supply has provisions for monitoring the subcarrier-level input to the discriminator.

The unit is a 2-7/16-inch by 13/16-inch modular chassis which mounts in the Model 222A Rack Adapter.

Detailed information is available on the Model 223G Power Supply in a separate manual.

1.3.4 Model 222A Rack Adapter

Three standard versions of the rack adapter are available for use with the Model 229 system. Differences are in the electrical connectors mounted on the rear panel as shown in Figure 3-3. The Model 222A-01-0999B has four Kulka type-600-Y-20 terminal strips, the Model 222A-02-0999B has two AMP type-581342-3 taper-pin blocks and one Hubbell type-746 plug for system interconnections, and the Model 222A-03-0999B has four Kulka type-600-Y-20 terminal strips and one Hubbell plug.

The rack adapter occupies 5-1/4 inches of panel height in a standard 19-inch rack, and the overall depth behind the panel is 18-3/8 inches including terminal connectors. The connectors are wired to barrier strips on the rear of the rack adapter. Power supply, discriminator, and channel-selector/output-filter units are positioned and guided into the rack adapter from the front by anodized aluminum T rails.

The rack adapter is fabricated from spot-welded steel with open construction, permitting unrestricted flow of cooling air. A locking-bar assembly that extends across the front of the rack adapter is available to prevent accidental release of the modular units during transportation of portable cases and in shock or vibration environments such as are experienced in aircraft, on shipboard, and in mobile instrumentation vans.

- i. Tape-Speed Compensation: Tape-speed errors can be compensated with the use of an external delay network.
- j. Linearity: For $\pm 7.5\%$ subcarrier-frequency deviation, the best-straight-line linearity is at least $\pm 0.1\%$ of bandwidth; for a $\pm 15\%$ deviation, at least $\pm 0.2\%$ of bandwidth.
- k. Output Noise: The RMS value of output noise is less than 0.2% of the full-bandwidth voltage.
- l. Output-Zero Stability: $\pm 0.3\%$ of bandwidth in a 15-hour period after a 15-minute warm-up.
- m. Deviation-Sensitivity Stability: $\pm 0.2\%$ in a 15-hour period after a 15-minute warm-up.
- n. Output Voltage: Single-ended and referenced to ground. The deviation sensitivity is negative. A front-panel control provides means for varying the output voltage at bandedge between 1 and 10 volts.
- o. Output Current: 100 Ma capability from DC to 5 Kc, decreasing linearly to 50 Ma at 30 Kc.
- p. Output Impedance: 2 ohms or less at a bandedge output of 10 volts, decreasing linearly to 0.2 ohm or less at 1 volt.
- q. Harmonic Distortion: For deviation ratios of 5 or more and with modulation extending from bandedge to bandedge, 1% or less for any modulation frequency up to the cutoff frequency of the channel.
- r. Discriminator Data Response: The response of the output filter can be constant amplitude or constant delay, as determined by a front-panel switch. Both responses roll off at an 18-Db per octave rate beyond cutoff.

With a constant-amplitude filter and a deviation ratio of 5 or greater, the amplitude of the discriminator data response is down nominally 0.5 Db at the cutoff frequency and is essentially the third-order Butterworth response. The data response is down a minimum of 7 Db at two times the cutoff frequency and 25 Db at four times the cutoff frequency.

With the constant-delay filter and a deviation ratio of 5 or greater, the time delay of the discriminator data response is constant within 5%. The specified cutoff frequency is the nominal 3-Db frequency. The data response of the discriminator is down a minimum of 10 Db at two times the cutoff frequency and 25 Db at four times the cutoff frequency.

SECTION 2

SPECIFICATIONS

2.1 INTRODUCTION

This section contains a complete listing of electrical, physical, and environmental equipment specifications.

2.2 ELECTRICAL SPECIFICATIONS

The following electrical specifications apply to both Model 229A-01 and Model 229A-02 except where noted.

- a. Subcarrier Frequencies: Center frequency between 300 CPS and 300 Kc (Model 229A-01) or 100 CPS and 100 Kc (Model 229A-02), tuned by front-panel switch and dial.
- b. Subcarrier Frequency Deviation: $\pm 7.5\%$ or $\pm 15\%$, determined by a front-panel switch.
- c. Deviation Ratio: 1, 5, 10, 25, 50, or 100, determined by a front-panel switch. When a deviation ratio of 1 is selected, the phase-locked loop will not lose lock with a step of subcarrier frequency from bandedge to bandedge.
- d. Data Frequencies: 3 CPS to 30 Kc, determined by a front-panel switch and dial.
- e. Input Impedance: Greater than 100,000 ohms.
- f. Dynamic Input-Signal Range: 10 millivolts to 5 volts RMS (54 Db) for subcarrier frequencies from 300 CPS to 30 Kc. Above 30 Kc, the minimum input signal increases linearly to 50 millivolts at 300 Kc. Each subcarrier signal in the subcarrier multiplex can be as great as 5 volts RMS.
- g. Amplitude-Modulation Rejection: With a deviation ratio of 5, a 20-Db step of input amplitude anywhere in the 54-Db dynamic input range causes a peak transient of less than 1% bandwidth for subcarrier frequencies from 300 CPS to 30 Kc; less than 1.5% of bandwidth from 30 Kc to 300 Kc.
- h. Rejection of Unwanted Signals: Full-scale modulation of an adjacent $\pm 7.5\%$ deviation IRIG channel causes an RMS error of less than 0.1% of bandwidth even when the interfering signal has an amplitude 6 Db greater than the desired signal.

- s. Output-Voltage Limit: Output voltage is limited to 350% of the bandedge voltage or to 15 volts, whichever is less.
- t. SIGNAL LOSS Light: When the input-signal amplitude is less than a preset zero-signal level, a neon lamp on the front panel illuminates and the discriminator output is grounded. The zero-signal level is adjustable up to 25 millivolts RMS and is normally adjusted at the factory to 5 Mv at bandcenter. This adjustment enables the operator to set the zero-signal level for optimum signal-to-noise performance and convenience of operation.
- u. LOCK LOSS Light: A neon lamp on the front panel provides visual indication of loss-of-lock operation.
- v. SUBCARRIER AMPLITUDE Meter: A meter on the Model 223G Power Supply indicates the amplitude of the sub-carrier signal at the output of the bandpass input filter, referenced to the subcarrier-signal center-frequency amplitude at the discriminator input. Five ranges are provided: 0.1, 0.3, 1.0, 3.0, and 10 volts.
- w. Line-Voltage Sensitivity: A 10-volt step of line voltage anywhere between 108 and 132 volts causes a peak transient of less than 0.2% of bandwidth at the output of the discriminator.
- x. Power Requirement: 108 to 132 volts, 47 to 420 CPS, single phase (20 watts at 120 volts).

2.3 PHYSICAL SPECIFICATIONS

Physical specifications are identical for both Model 229A-01 and Model 229A-02.

a. Panel Size:

1. Model 229A Tunable Channel Selector/Output Filter--Height; 5-1/4 inches. Width; 13 inches.
2. Model 210A Data Discriminator--Height; 5-1/4 inches. Width; 1-5/8 inches.
3. Model 223G Power Supply--Height; 5-1/4 inches. Width; 2-7/16 inches.
4. Complete Model 229--Height; 5-1/4 inches. Width; 19 inches.

- b. Overall Depth: 16-3/8 inches excluding projections from the front panel.
- c. Weight:
 - 1. Complete Model 229 in Model 222A Rack Adapter-- 41-1/4 pounds.
 - 2. Model 229A--12 pounds.
 - 3. Model 210A--3-3/4 pounds.
 - 4. Model 223G--11 pounds.
 - 5. Model 222A--14-1/2 pounds.
- d. Panel Finish: Blue iridescent acrylic lacquer with white lettering is standard.
- e. Mounting: Occupies one complete Model 222A Rack Adapter, which is designed for mounting in a standard EIA-type rack providing room for 19 inches of panel width.

2.4 ENVIRONMENTAL SPECIFICATIONS

Environmental specifications are identical for both the Model 229A-01 and the Model 229A-02.

- a. Operating Temperature Range: +10°C to +50°C circulating air.
- b. Storage Temperature Range: -55°C to +85°C circulating air.

SECTION 3

INSTALLATION AND OPERATION

3.1 GENERAL

This section contains information describing the installation and operation of the Model 229 Tunable Discriminator.

3.2 INSTALLATION

3.2.1 Unpacking

The four subunits of the Model 229 are each packaged separately and shipped in a single carton. After unpacking, inspect equipment for physical damage that may have resulted from shipping. Any shortages or damage to the units should be reported immediately in accordance with instructions of the EMR Purchase Order Acknowledgment (POA).

3.2.2 Mounting

The modular units of the Model 229 Tunable Discriminator plug into the Model 222A Rack Adapter. During installation, the Model 210A Discriminator Chassis must be plugged in before the Model 229A Tunable Channel Selector/Output Filter.

The rack adapter occupies 5-1/4 inches of panel height in a standard 19-inch rack. The rack adapter is prewired internally to provide wiring connections between modular units. Figure 3-1 shows the chassis layout in the rack adapter.

The Model 229A is illustrated as overlapping the Model 210A. This provides for direct interconnection between the two units and eliminates excessive cabling. Physical dimensions are illustrated in Figures 3-2 and 3-3.

CAUTION

When removing modular units from rack adapter, the Model 229A Tunable Channel Selector/Output Filter must be removed before removing the Model 210A Discriminator Chassis.

External wiring connections to the rear of the three types of rack adapters are given in Figure 3-4.

3.2.3 Cooling

Adequate cooling must be provided to limit the ambient operating temperature of the equipment to a maximum of 50°C. The Model 222A Rack Adapter is open at the top and bottom for natural convection or forced-air cooling.

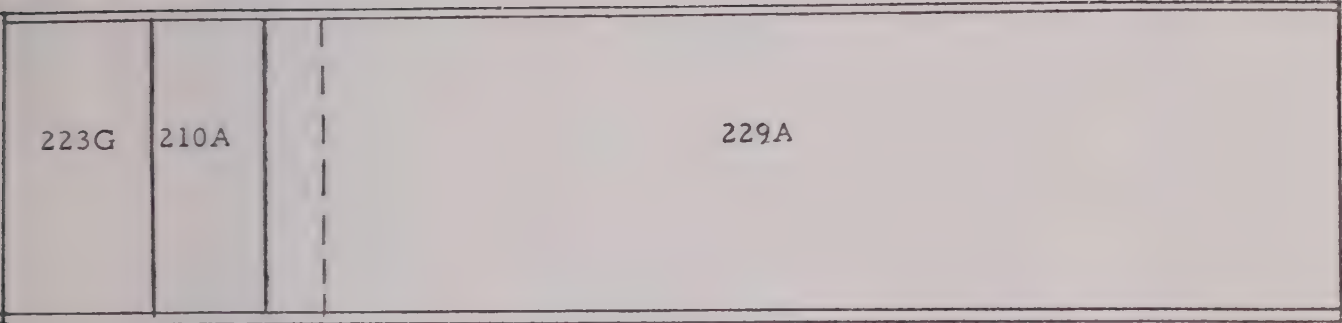
3.3 LOCATION AND FUNCTION OF CONTROLS AND INDICATORS

Controls and indicators used in the operation of the Model 229 Tunable Discriminator are shown for each module in Figures 3-5 through 3-7 and described in Tables 3-1 through 3-3.

3.4 OPERATING PROCEDURES

Operation of the Model 229 Tunable Discriminator consists of setting up front-panel controls in accordance with input signal characteristics and desired data output characteristics.

No particular sequence of operation is necessary. It is recommended that the operator become thoroughly familiar with the purpose and function of each front-panel control to obtain the most beneficial results. A brief description of each control function is covered in Tables 3-1 through 3-3. The detailed circuit function is covered in Section 4, Theory of Operation.



. 1 . 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9 . 10 . 11 . 12 . 13 . 14 . 15 . 16 . 17 . 18 . 19 . 20 . 21 .

RACK ADAPTER LAYOUT

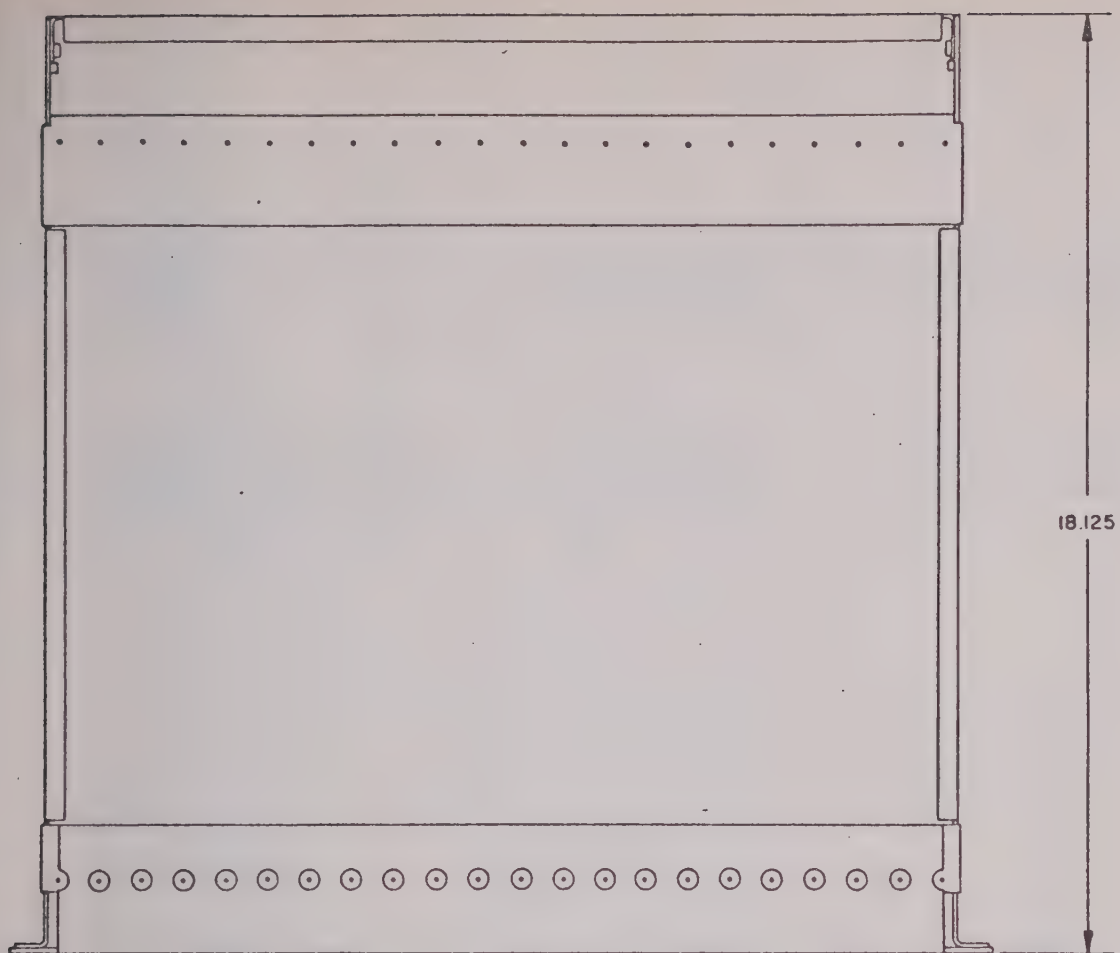
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	J21
X				X														X		

CONNECTOR LOCATIONS

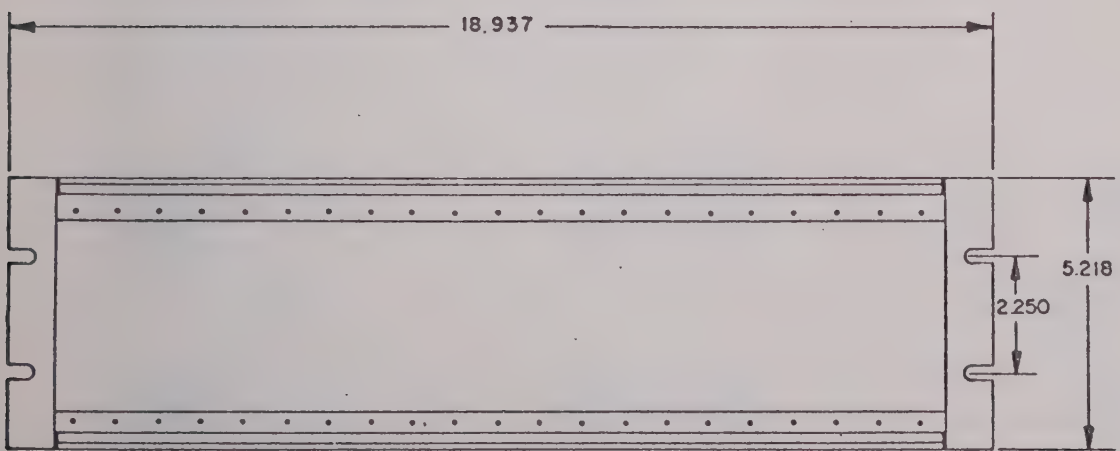
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X			X			X															X

GUIDE RAIL LOCATIONS

Figure 3-1. Model 222A Rack Adapter, Chassis Layout



TOP VIEW



FRONT VIEW

Figure 3-2. Rack Adapter Physical Dimensions and Mounting Requirements

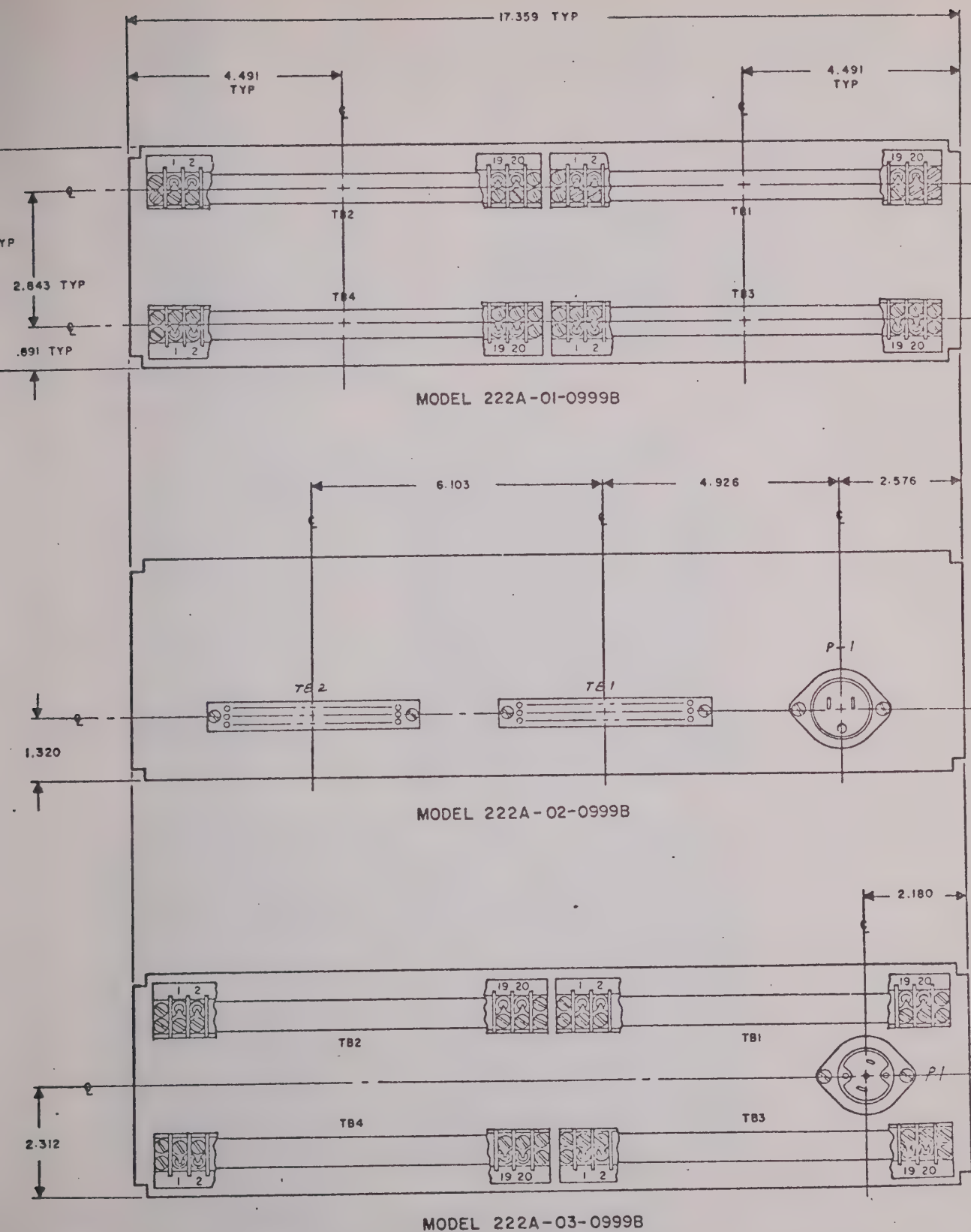


Figure 3-3. Rack Adapter Rear Connector Locations

TB-1		TB-2		TB-3		TB-4	
PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1		1		1		1	
2		2		2		2	
3		3		3		3	
4		4		4		4	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	
9		9		9		9	
10		10		10		10	
11		11		11		11	
12		12		12	GROUND	12	
13		13		13	DISC TSC INP	13	
14		14		14	GROUND	14	
15		15		15	DISC INP LEV	15	
16		16		16	GROUND	16	
17		17		17	DISC. OUTPUT	17	
18	115V AC	18		18	GROUND	18	
19	115V AC	19		19	DISC. INPUT	19	
20	CASE GROUND	20		20	GROUND	20	

MODEL 222A-01-0999B

PI		TB-1		TB-2	
PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1	115V AC	A		A	
2	115V AC	B		B	
3	CASE GROUND	C		C	
		D		D	
		E		E	
		F		F	
		G		G	
		H		H	
		J		J	
		K		K	
		L		L	
		M	GROUND	M	
		N	GROUND	N	
		P	DISC. INPUT	P	
		R	DISC. OUTPUT	R	
		S	DISC INP LEV	S	
		T	DISC TSC INP	T	
		U		U	
		V	CASE GROUND	V	
		W		W	

MODEL 222A-02-0999B

TB-1		TB-2		TB-3		TB-4	
PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1		1		1		1	
2		2		2		2	
3		3		3		3	
4		4		4		4	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	
9		9		9		9	
10		10		10		10	
11		11		11		11	
12		12		12	GROUND	12	
13		13		13	DISC. TSC INP	13	
14		14		14	GROUND	14	
15		15		15	DISC INP LEV	15	
16		16		16	GROUND	16	
17		17		17	DISC OUTPUT	17	
18		18		18	GROUND	18	
19		19		19	DISC INPUT	19	
20	CASE GROUND	20		20	GROUND	20	

MODEL 222A-03-0999B



PIN	FUNCTION
1	115V AC
2	115V AC
3	CASE GROUND

Figure 3-4. Rack Adapter, External Wiring Schedule

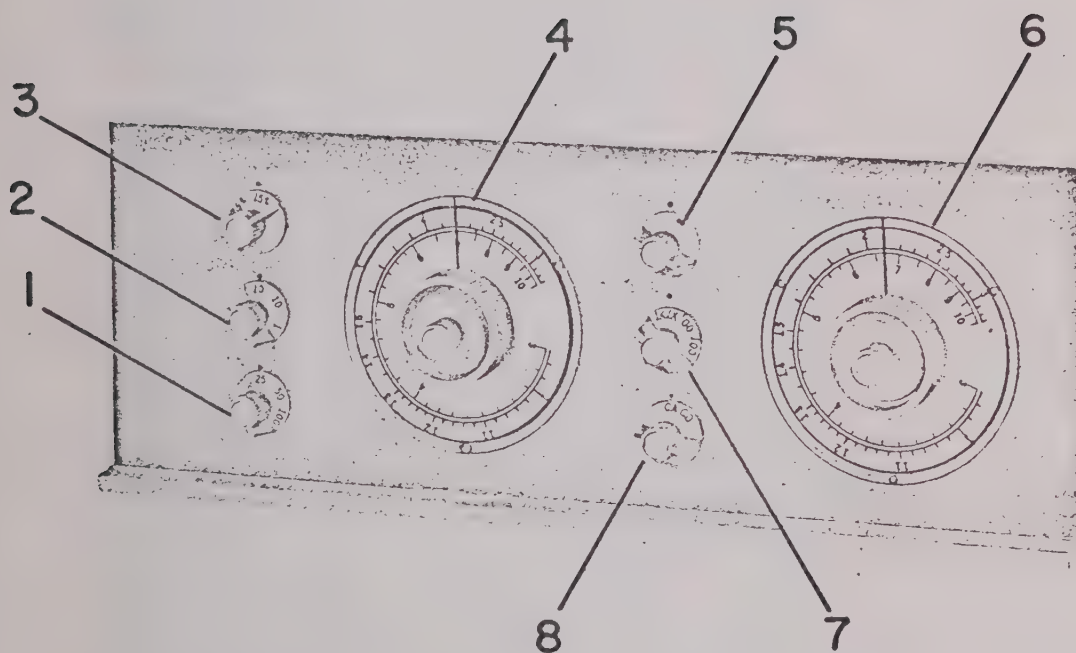


Figure 3-5. Model 229A Tunable Channel Selector/Output Filter,
Location of Controls and Indicators

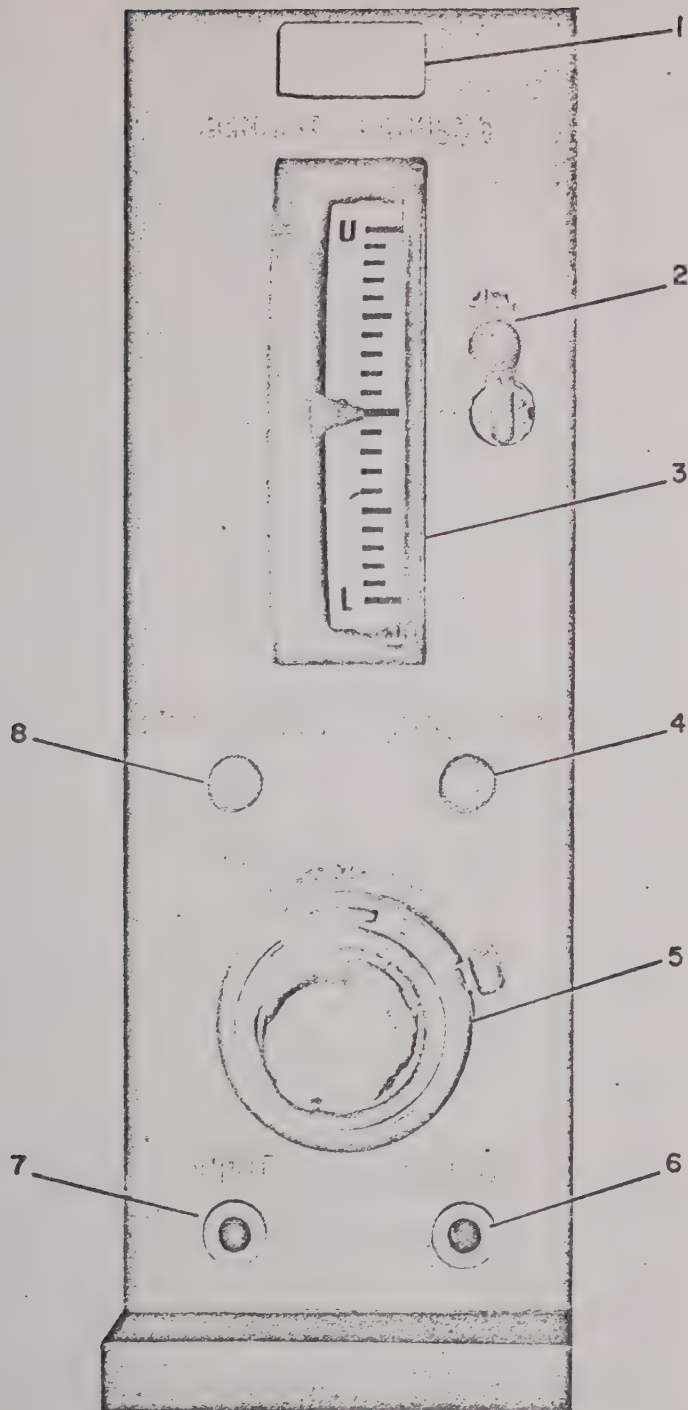


Figure 3-6. Model 210A Discriminator
Location of Front-Panel Controls and Indicators (Ref. Table 3-2)

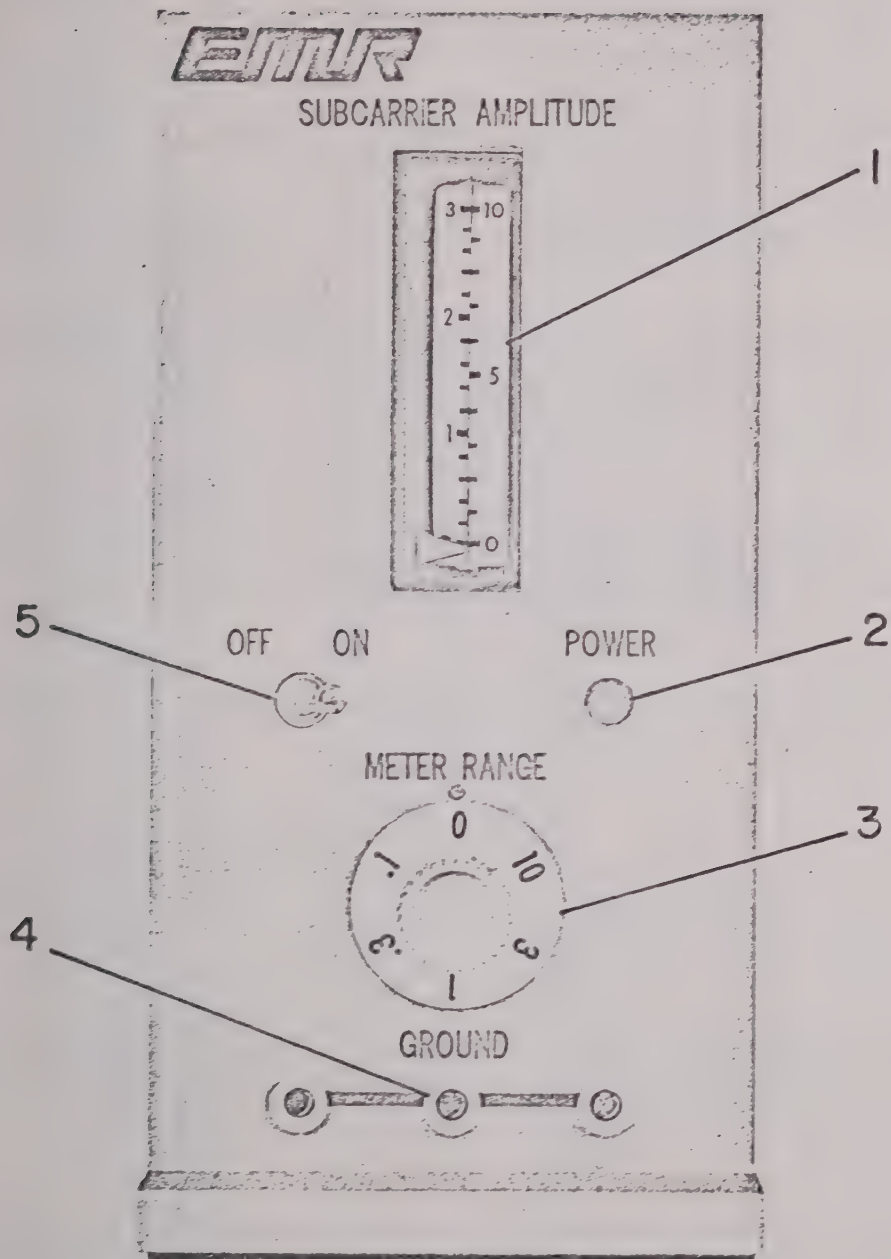


Figure 3-7. Model 223G Power Supply,
Location of Controls and Indicators (Ref. Table 3-3)

Table 3-2. Model 210A Discriminator,
Function of Front-Panel Controls and Indicators (Ref. Figure 3-6)

REF. NO.	NAME	DESIG-NATION	TYPE	FUNCTION
1	System Designator	None	Lettered plastic tag	Specifies assigned location of discriminator.
2	DEV Switch	7SW901	Toggle switch	Allows selection of negative or positive deviations sense (used on Models 210A-04 and 210A-05 only).
3	PERCENT BANDEDGE Meter	4M201	Center-balance movement; ± 3.0 -volt full-scale deflection with multiplier/resistor	Indicates the percentage of bandwidth.
4	LOCK LOSS Indicator	4DS302	90-volt neon lamp	Lights to indicate loss of lock of the phase-locked-loop FM detector.
5	BANDEDGE VOLTS Control	4R636	9-turn, 900-ohm potentiometer	Used to adjust output-voltage amplitude.
6	OUTPUT Test Jack	4J601	White TP jack	Used to monitor output.
7	INPUT Test Jack	4J101	White TP jack	Used to monitor output of BPIF.
8	SIGNAL LOSS Indicator	4DS301	90-volt neon lamp	Lights to indicate input signal less than a predetermined level.

Table 3-3. Model 223G Power Supply, Function of Controls and Indicators
(Ref. Figure 3-7)

REF. NO.	NAME	DESIG- NATION	FUNCTION
1	SUBCARRIER AMPLITUDE Meter	M1	Indicates amplitude of subcarrier signal at output of discriminator bandpass input filter, but referenced to the subcarrier signal amplitude at the input to the discriminator at center frequency.
2	POWER Indicator Lamp	DS1	Lights when power is applied to the Model 229 Tunable Discriminator.
3	METER RANGE Switch	S101	Provides full-scale meter ranges of 0.1, 0.3, 1.0, 3.0, and 10 volts for the SUBCARRIER AMPLITUDE meter.
4	GROUND Test Jack (3)	J2, J3, J4	Ground test-point jacks.
5	OFF/ON Power Switch	S1	Controls AC voltage input.

SECTION 4

THEORY OF OPERATION

4.1 GENERAL

This section describes the theory of operation of the Model 229 Tunable Discriminator. Overall system theory is discussed first with reference to the broad block diagram shown in Figure 4-1. A more detailed description is then covered on a subsystem basis with reference to overall and simplified schematic diagrams. Simplified schematics, when used, are placed in this section with the text; all complete schematics are placed in Section 5.

4.2 SYSTEM OPERATION

The FM subcarrier multiplex input signal is applied to the bandpass input filter (BPIF) located in the Model 229A (see Figure 4-1). The BPIF is tuned by means of a front-panel control to accept one individual subcarrier channel of the total FM multiplex. The single channel output signal of the BPIF is applied to a limiter which maintains a constant-amplitude square-wave output over a 54-Db dynamic input signal range (10 Mv to 5 volts RMS). The BPIF output is also applied to a SUBCARRIER AMPLITUDE meter located on the Model 223G Power Supply. The meter indicates the RMS magnitude of the subcarrier signal at the output of the BPIF.

The limiter output square wave is applied to a phase-locked-loop FM detector for detection of the selected FM subcarrier. The phase-locked-loop FM detector provides improved signal-to-noise performance compared to other means of FM detection. The phase-locked-loop detector consists of the phase detector, voltage-controlled oscillator (VCO), and loop amplifier and filter connected as a second-order feedback system. The DC component of the output of the phase detector is proportional to the phase error between the limiter and VCO signals; 90-degree phase shift is considered as the zero phase error reference. The phase-detector output is amplified and filtered by the loop amplifier and filter, and applied to the VCO in a manner to drive the oscillator to the same frequency as the limiter output signal and reduce the phase error to zero. The static frequency error is, therefore, always zero, and the DC component of the loop amplifier and filter output or VCO input signal is the detected signal.

The detected signal is filtered and amplified by the output amplifier and filter to provide a data output signal suitable for driving galvanometers, decommutators, etc.

The tunable low-pass output filter is an active filter which removes any frequency components above the cutoff frequency setting of the filter. The output filter may be tuned to any data-cutoff frequency from 3 CPS to 30 Kc by use of front-panel



Figure 4-1. Model 229 Tunable Discriminator, Functional Block Diagram

controls. Operation of the filter as either a constant-amplitude or constant-delay filter is selectable by front-panel controls.

All temperature-critical VCO components which may affect operating frequency are contained in a temperature-controlled oven. The oven temperature is controlled electronically, thereby maintaining highly stable performance of the VCO.

A lock-loss circuit is incorporated to provide indications of loss-of-lock operation and poor input-signal quality. Also included is a signal-loss circuit which provides indication of low input-signal level and clamps the discriminator data output to ground for input signal amplitudes less than a preset level.

All power required by the Model 229 Tunable Discriminator is supplied by the Model 223G Power Supply. Power regulators in the Model 210A provide regulated voltage to all critical circuits in the Models 210A and 229A.

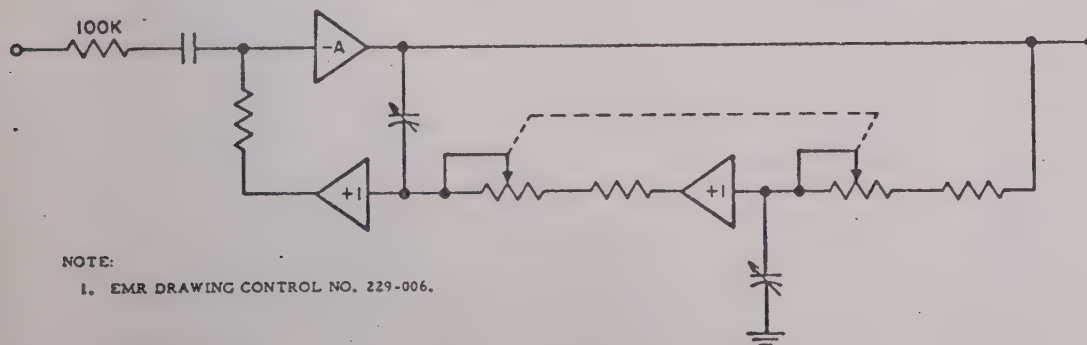
4.3 DETAILED THEORY OF OPERATION

The following paragraphs contain detailed theory of operation of the Model 229 Tunable Discriminator on a subsystem basis. Reference should be made to the simplified schematics in this section and also the overall schematics in Section 5.

4.3.1 Bandpass Input Filter

All components of the bandpass input filter (BPIF) are located in the Model 229A Tunable Channel Selector/Output Filter. Since components of the filter are located on various cards of the Model 229A, a simplified schematic of the complete filter is shown in Figure 4-2.

The tunable bandpass input filter employed in the Model 229 is a 2-pole, active-type filter. The filter configuration of each pole is basically a feedback amplifier with a band-reject bridge-T feedback network. The basic functional configuration of one pole is as shown below.



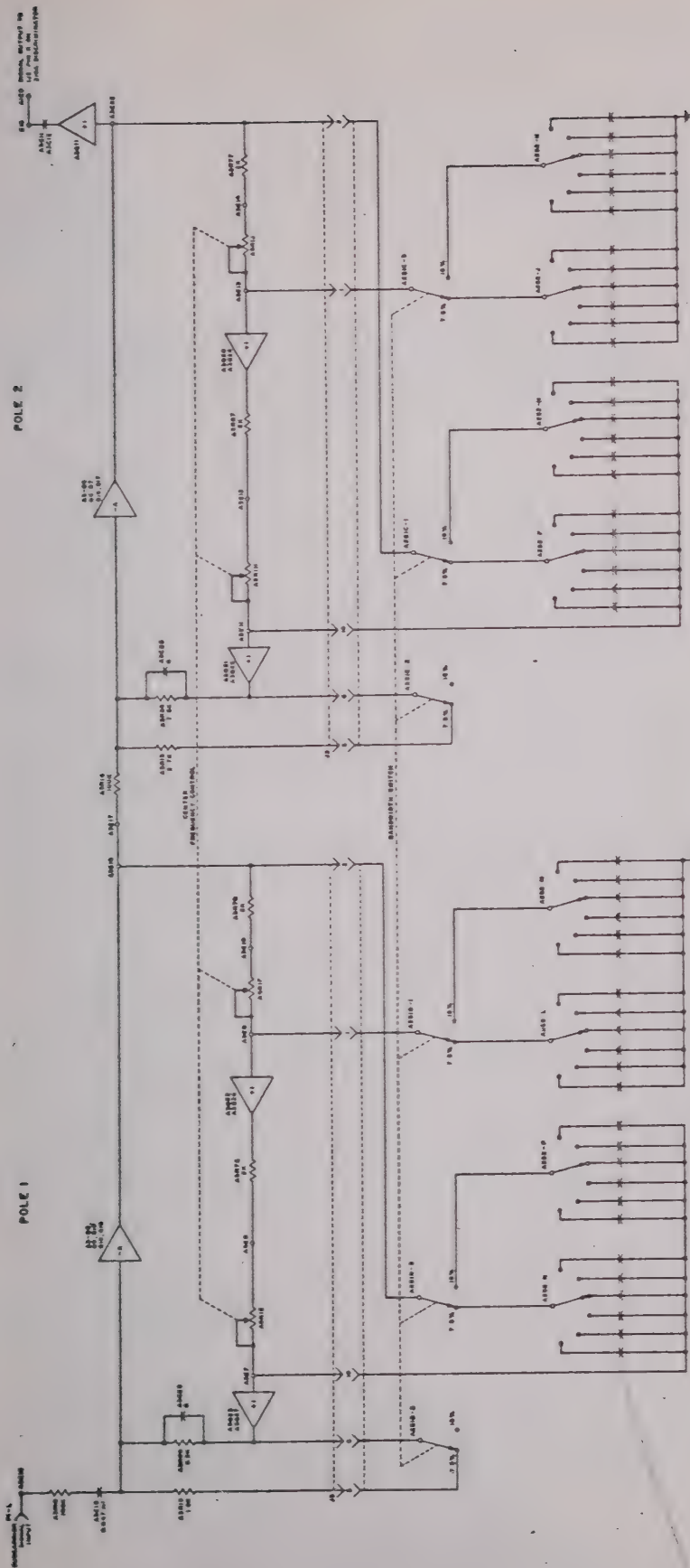


Figure 4-2. Bandpass Input Filter, Simplified Schematic Diagram

input impedance of the filter is a fixed, 100K ohms established by resistor 1R18. The passband frequency range is determined by a bank of capacitors selectable through switch A2S2. Continuous tuning within the selected passband is accomplished by A5R1. The +1 amplifiers are unity-gain, noninverting type with high input and low output impedances. These amplifiers are used to isolate portions of the feedback network, thereby eliminating interaction between filter components during tuning. The -A amplifier has an open loop voltage gain of approximately 1000.

Narrow-band or wide-band operation is determined by the position of front-panel BANDWIDTH switch A2S1. The filter bandwidth ($\pm 7.5\% F_c$ or $\pm 15\% F_c$) is changed by changing the ratio of the two timing capacitors in each section.

1.3.2 Limiter

Components of the limiter circuit are located on the Model 210A Discriminator main printed-circuit card. The main card schematic diagram is shown in Figure 5-19. Three limiting stages are employed to provide the 54-Db dynamic-input signal range capabilities of the discriminator. The first stage is a nonlinear voltage divider consisting of resistor 1R120 and diodes 1CR102 and 1CR103 connected in parallel in reversed polarity. The input to the divider is a sinusoidal signal with an amplitude range of 5 millivolts RMS to 5 volts RMS. The diodes have high resistance for voltages less than 0.64 volt, and low resistance for voltage greater than 0.64 volt; the output voltage of the nonlinear divider is thus limited to 0.64 volt peak. The output of the first limiter stage is isolated from the following two limiter gain stages by a follower consisting of transistors 1Q104 and 1Q105.

The second limiter stage consists of transistors 1Q106 and 1Q107, and the third limiter stage consists of transistors 1Q108 and 1Q109, connected as operational amplifier gain stages employing diodes as nonlinear feedback elements to limit their output voltage. Each gain stage consists of a common-emitter amplifier and an output emitter follower. AC coupling and DC inverse feedback are employed for temperature stabilization. The output of the second limiter stage is limited to 0.64 volt peak, the forward voltage of diodes 1CR104 and 1CR105. The output of the third limiter stage is set to 2.5 volts peak by the reverse bias applied by a resistive divider consisting of 1R113, 1R124, 1R132, and 1R133.

Inverted limiter outputs are provided by transistor 1Q111. Transistor 1Q110 is connected as an emitter follower to drive the lock-loss circuit and the limiter output test point (TP3).

The linear gain of the limiter is approximately 2000, with 3-Db frequencies of 50 CPS and 500 Kc. For minimum input-signal level, only the third stage limits; for maximum input-signal level, all three stages limit.

3.3 Phase Detector, Loop Amplifier, and Loop Filter

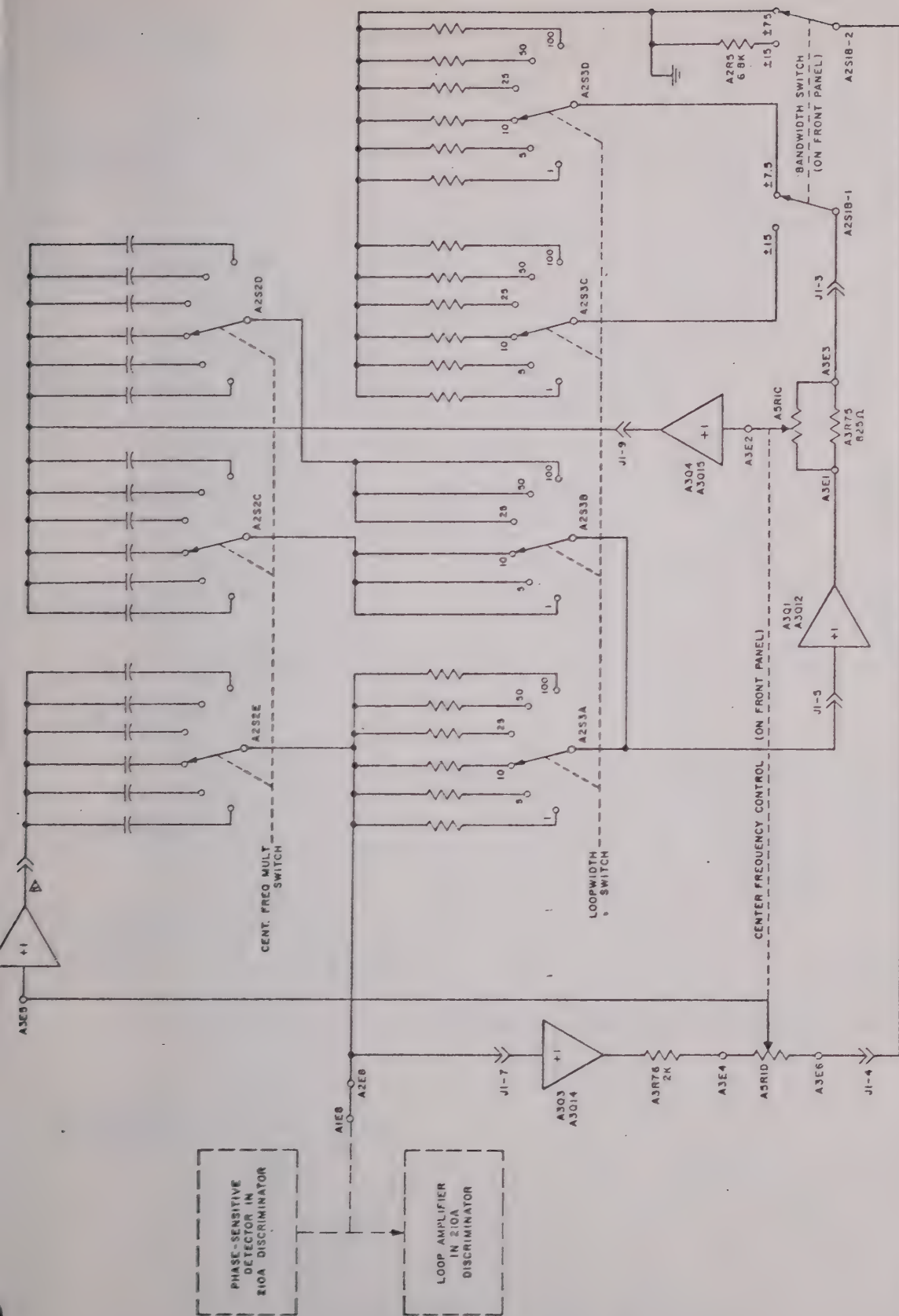
The phase detector and loop amplifier are part of the Model 210A Discriminator Chassis. All components of these circuits are located on the main printed-circuit card shown in Figure 5-18. The loop filter components are located in the channel selector section of the Model 229A Tunable Channel Selector/Output Filter. A simplified schematic of the loop filter is shown in Figure 4-3. Card schematics of cards containing components of the loop filter are shown in Figures 5-11, 5-13, and 5-15.

This circuitry provides combined phase detection, amplification, and filtering with complementary elements for temperature stabilization. The phase detector consists of transistors 1Q207 and 1Q209 connected as constant-current generators. These transistors are turned on by coincidence of the input signals to a pair of AND gates. The input signals to the AND gates are derived from the inverted output signal pairs from the limiter and VCO. Loop amplifier gain and filtering are obtained by passing the phase detector output current through a selective loop filter network contained in the Model 229A Tunable Channel Selector/Output Filter.

Phase-detector and loop-amplifier waveforms are shown in Figure 4-4. Current generator A (1Q207) is turned on by the coincidence of positive limiter output A and positive VCO output A voltages at the bases of AND-gate transistors 1Q205 and 1Q206 (refer to waveforms 1, 2, and 3).

These positive pulses turn off 1Q205 and 1Q206 which removes ground from the emitter of 1Q207, allowing 1Q207 to conduct. Current generator B (1Q209) is similarly controlled by limiter output B and VCO output B signals (refer to waveforms 4, 5, and 6). A constant -1 Ma current drawn primarily from the loop-filter capacitor (5C203), is provided by current generator C (1Q202). The currents provided by generators A, B, and C are summed in the bus connected to the collectors of transistors 1Q202, 1Q207, and 1Q209. The sum is a square-wave current signal of ± 1 Ma peak magnitude about zero with a frequency twice the limiter or VCO frequency (refer to waveform 8).

Amplification of the phase-detector output is accomplished by allowing the phase-detector current to flow through a high-value resistor (1R210) and coupling to other discriminator circuitry through a loop amplifier follower with high input impedance and high current gain (transistors 1Q203, 1Q204, and 1Q211). Since the value of resistor 1R210 is 150K ohms, the peak output voltage of the loop amplifier follower would be 150 volts for a 90-degree error signal from the phase detector (refer to hypothetical waveform 9). The maximum signal range at the loop amplifier output is ± 9 volts. Clipping would occur at this level if the signal were not smoothed by the loop filter. The frequency-determining elements of the loop filter (Figure 4-3) determine the operating characteristics of the phase-locked-loop detector. The loop-amplifier output, with the loop filter, is shown in waveform 10).



NOTES:

- 1 J1-8 FOR MODEL 229A-01, J4-1 FOR MODEL 229A-02.
- 2 A1 = PLUG CARD
- 3, A2 = SWITCHING CARD
- 4, A3 = ELECTRONIC CARD
5. EMR DRAWING CONTROL NO. 229-003.

Figure 4-3. Loop Filter, Simplified Schematic

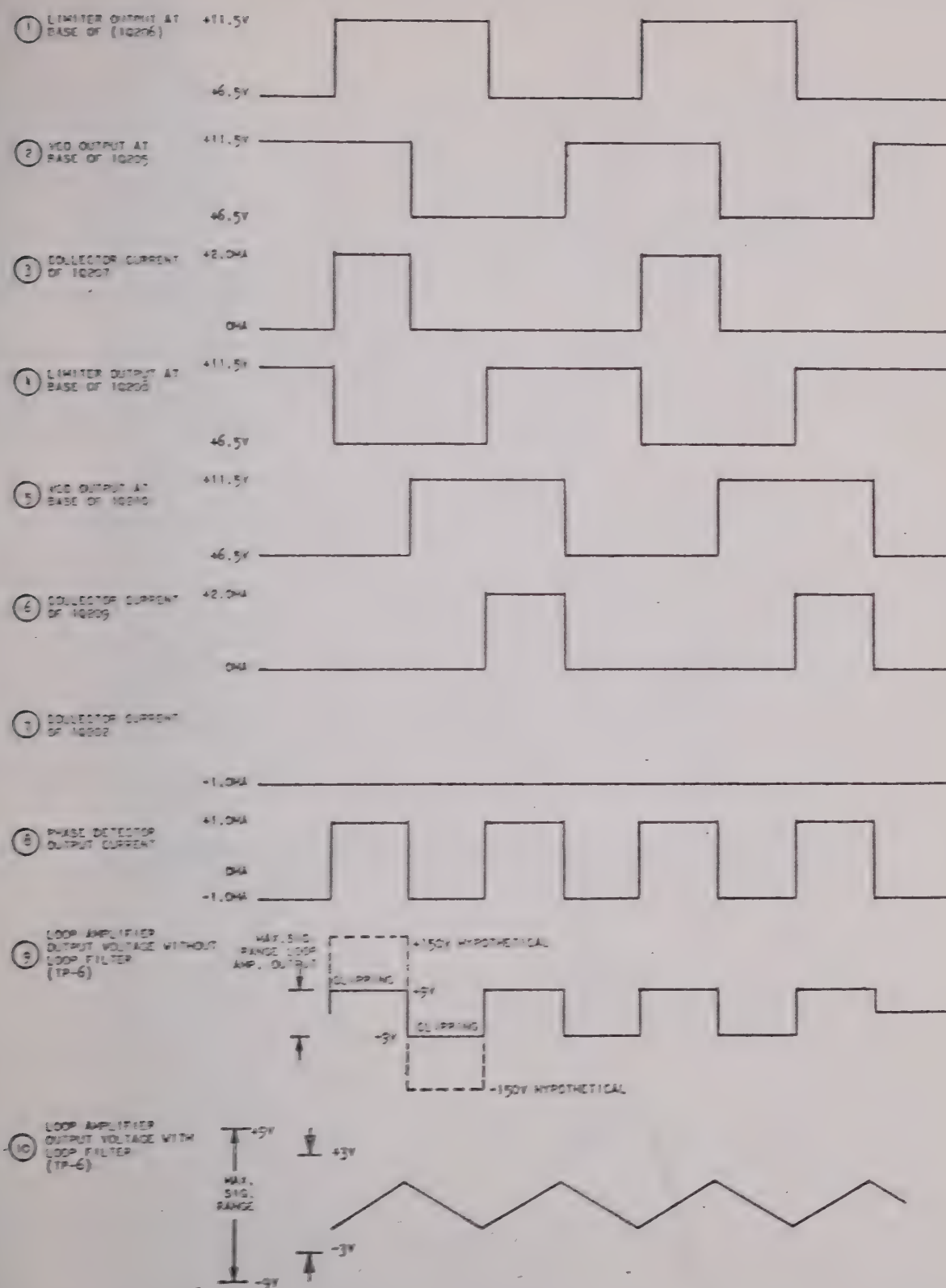


Figure 4-4. Idealized Waveforms, Phase Detector and Loop Amplifier

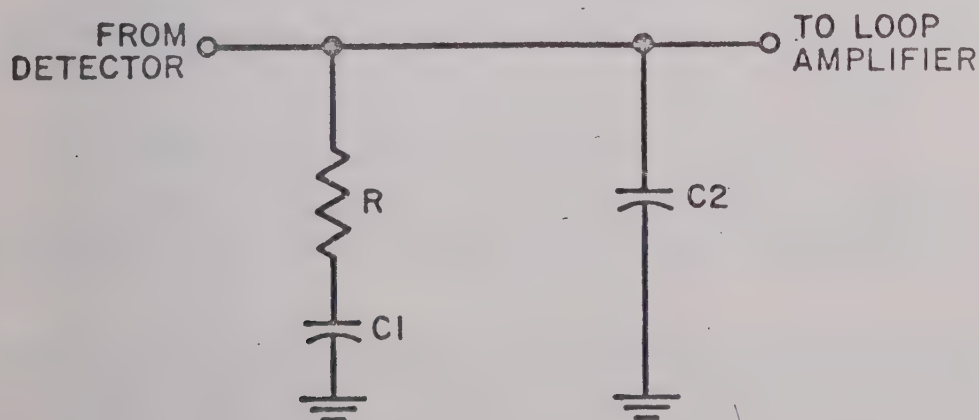
The phase detector/loop amplifier combination has a DC gain of 50 which provides output voltage required to drive the voltage-controlled oscillator to band-edge (3.0 volts).

The static phase-locked-loop phase error, the phase error at bandedge, is 90 degrees divided by the DC loop gain, or less than 2 degrees. This low static phase error does not significantly deteriorate the signal-to-noise efficiency of the phase-locked-loop detector. Additional phase errors due to temperature drift in this circuitry are avoided by the complementary arrangements of the current generators. The limiter output signals are AC coupled to the phase detector coincidence gates and their switching levels are set; therefore, the phase detector also provides additional input-signal limiting.

The static phase error may be adjusted to zero degrees at bandcenter by means of the phase balance control, 1R204, which sets the output of current generator C (1Q202). The limiter and VCO output signals can be monitored at test points TP3 and TP4.

The waveforms shown in Figure 4-4 are with zero phase error between the limiter and VCO signals (90-degree phase displacement). During normal operation of the phase-locked-loop detector, modulation of the FM subcarrier results in a dynamic phase error in the linear range of ± 90 degrees. The duty cycle of the rectangular wave shown in waveform 8 is dynamically modulated and the average signal represents the detected data signal. The output of the loop amplifier is then the data signal with the ripple (twice the subcarrier frequency) shown in waveform 10 superimposed. The second harmonic ripple is removed from the discriminator data output by the output filter.

The basic functional configuration of the loop filter is as shown below.

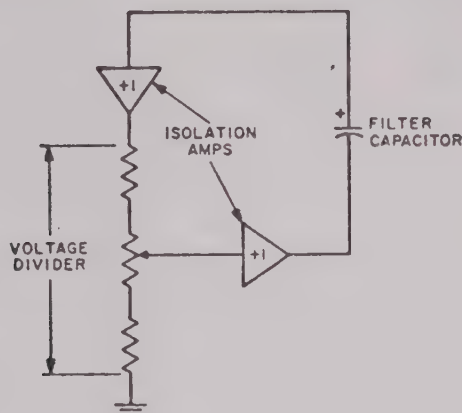


Basic Loop Filter

As shown in Figure 4-3, values of the three basic filter components are changed through use of front-panel controls. The R value is selected by the LOOPWIDTH

switch which determines the loop-filter cutoff frequency for each modulation index. The C values are selected by the CENT FREQ MULT switch to determine the center frequency range. Tuning within the selected center-frequency range is accomplished by CENTER FREQUENCY KC control.

The method used in obtaining tuning control is through use of the circuit configuration shown below.



Loop Filter Tuning

The +1 amplifiers are high-input impedance, low-output impedance, noninverting amplifiers with unity gain. Due to the amplifier characteristics, one side of the filter capacitor is effectively connected to the center tap of a voltage divider network. As the DC voltage level is varied at the potentiometer center tap, the voltage across the filter capacitor varies. This changes the effective charging level and thereby the effective capacity of the filter capacitor.

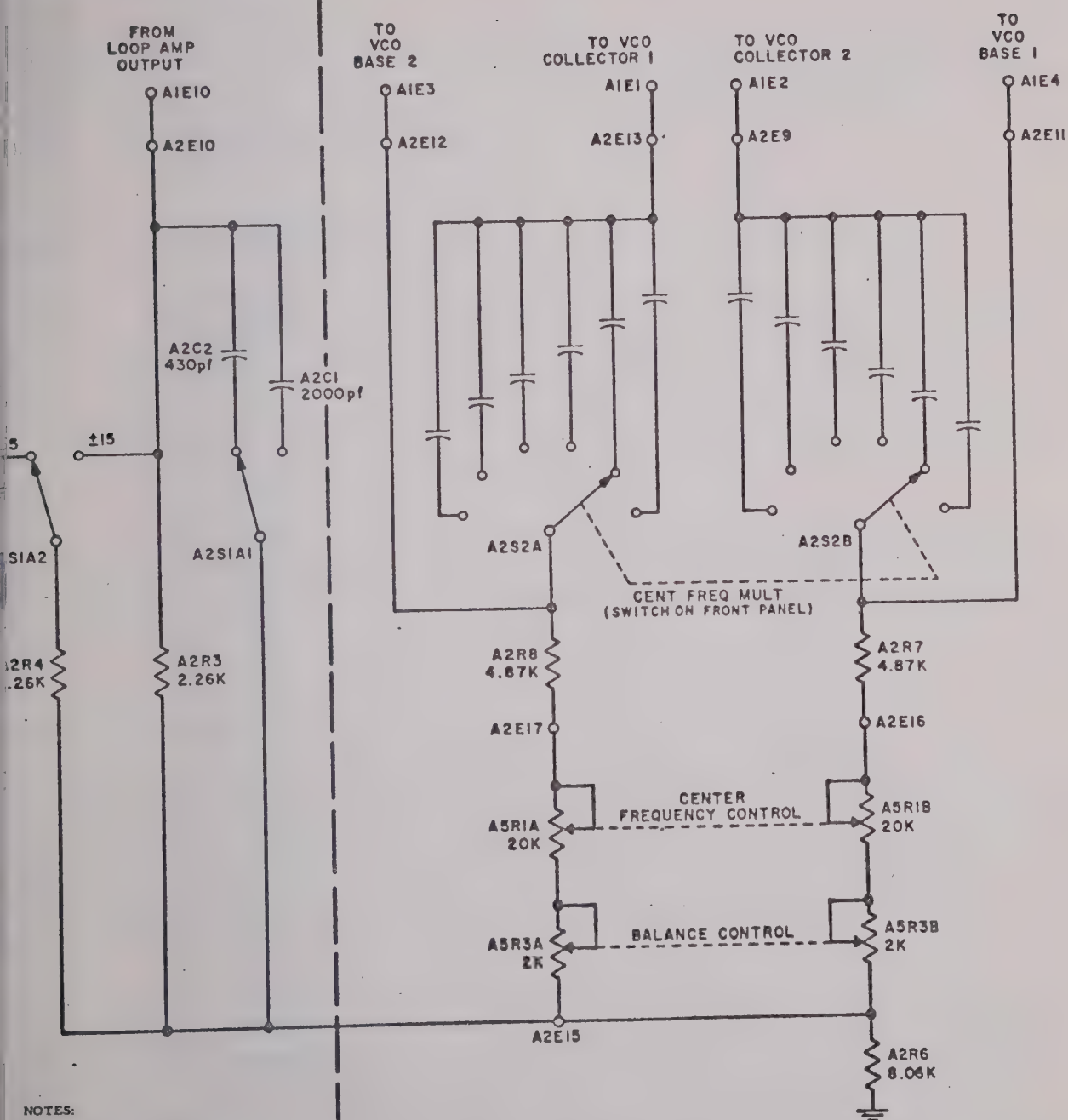
4.3.4 Voltage-Controlled-Oscillator Circuits

The voltage-controlled oscillator (VCO) circuits consist basically of a modified astable multivibrator, a bistable multivibrator, and associated tuning control circuits.

The astable multivibrator transistors (3Q405 and 3Q406) are located on the Model 210A oven card, Figure 5-24. The timing components and deviation sensitivity components shown in Figure 4-5 are located on the channel selector section of the Model 229A Tunable Channel Selector/Output Filter. Frequency of the astable multivibrator is controlled by front-panel controls; e.g., as the desired center frequency is selected by front-panel controls, the required timing capacitance and resistance are injected into the discharge current path of the astable multivibrator. The deviation sensitivity of the VCO is set by the resistive divider R3, R4, and R6 selected by the BANDWIDTH switch.

VCO DEVIATION SENSITIVITY COMPONENTS

VCO TIMING COMPONENTS



NOTES:
1. A1 = PLUG CARD
2. A2 = SWITCHING CARD
3. A3 = ELECTRONIC CARD

Figure 4-5. VCO Tuning, Simplified Schematic Diagram

The astable multivibrator output triggers a bistable multivibrator (1Q401 and 1Q402) located on the Model 210A main card assembly, Figure 5-19. The inverted square-wave output of the bistable is coupled to the phase detector.

The VCO design provides high linearity for the signal input and stability against power supply variations. Diode and transistor function polarities are reverse connected and operating currents are adjusted to provide a very low temperature coefficient. All transistors and diodes which can effect the VCO operating frequency are stable planar types; resistors are encapsulated low-temperature-coefficient metal-film types. The above considerations, the high stability of the power supplied, and the operation of the VCO in a controlled oven provide the highly stable performance of the VCO.

4.3.5 Inverting Amplifier

The inverting amplifier is used only in the Models 210A-04 and 210A-05 Discriminators. The amplifier, in conjunction with a DEV switch on the discriminator front panel, provides the discriminator with positive and negative sense capabilities. With the DEV switch in the (-) position, the amplifier is bypassed and normal negative sense is used. In the (+) position of the DEV switch, the signal is routed through the amplifier and inverted. This inverts the discriminator output thereby creating a positive sense discriminator.

The inverting amplifier obtains extreme stability by use of two differential amplifier stages (7Q901 through 7Q904) and a complementary emitter-follower output stage (7Q905 and 7Q906). The amplifier has unity gain and is DC coupled throughout.

4.3.6 VCO Oven Controller

All VCO components whose temperature would affect operating frequency are contained in a temperature-controlled oven. The VCO oven temperature is held at a constant 65°C by means of a contactless, continuous-control servo loop. Both the VCO and oven-controller components are contained in the oven; this system provides long-term stable operation without the unreliability, cycling, and resetting problems associated with mechanical-contact type thermostats.

The continuous-control servo operates by sensing the temperature electrically, comparing the voltage to a standard, and controlling the oven heater with the amplified error signal. The error signal is obtained from a resistive bridge consisting of 3RT501 (a thermistor), 3R506, 3R507, and 3R509. Transistor 3Q501 is a differential amplifier connected to amplify the bridge unbalance. One leg of the bridge is a temperature-sensitive resistor (thermistor); the bridge is in balance only at the temperature determined by the thermistor resistance/temperature characteristic and bridge adjustment (set for balance at 65°C by the value of 3R505 in parallel with 3R506). The bridge error signal is amplified by

transistors 3Q502, 3Q503, and 3Q504, and the output signal is applied to the oven heater 3HR501. This keeps the bridge in balance and the internal oven temperature constant regardless of the operating temperature of the discriminator.

4.3.7 Output Circuits

The output circuits consist of an output filter, a high-gain output amplifier, and a chopper amplifier for DC stabilization. These circuits are connected in the configuration of an analog low-pass Rauch¹ tunable filter which contributes 18 Db per octave to the total rolloff. All amplified components are located on the Model 210A secondary card assembly, Figure 5-20. The tunable filter components are located in the output filter section of the Model 229A Tunable Channel Selector/Output Filter. A simplified schematic of the filter configuration and the method of connecting into the output and chopper amplifiers are shown in Figure 4-6.

The loop amplifier output is applied through the frequency-determining components of the output filter to the output and chopper amplifiers. Dual-frequency inputs to the gain stages of the output amplifier are provided by a crossover network consisting of 2C604 and 2R627; the crossover frequency is 50 CPS. High frequencies are coupled directly into the output amplifier through 2C604; low frequencies and DC are coupled from the output of the chopper amplifier through 2R627. The low-frequency open loop gain of the output amplifier is 10,000.

The output amplifier consists of transistors 2Q601 through 2Q614 connected as a high-gain DC amplifier. The first stage is an emitter follower (2Q601) followed by two cascaded common-emitter amplifiers (2Q602 and 2Q603), another emitter follower (2Q604), and a common-emitter amplifier (2Q605), using a high-impedance load connected as a constant-current generator (2Q610). A complementary emitter follower (2Q606 and 2Q611) is used for isolation between the gain stages and the power-amplifier drivers. The driver stage is a complementary amplifier (2Q607, 2Q608, 2Q612, and 2Q613). The power output stage is a complementary emitter follower (2Q609 and 2Q614). The power transistors are mounted on a heat sink which is part of the secondary card assembly.

Diodes 2CR605 through 2CR608 are biased to conduct when the amplifier output exceeds ± 12.5 volts. When these diodes conduct, they feed the amplifier output back to the input in inverse phase and limit the amplifier output to ± 12.5 volts while maintaining closed-loop operation of both the output amplifier and chopper amplifier. Since circuitry in the loop cannot be saturated and coupling capacitors cannot be charged by an overload input signal, fast recovery time is achieved.

The input to the chopper amplifier is the DC error signal obtained from the feedback network of the Rauch output filter. AC components of this signal are filtered

¹M. H. Nichols, L. L. Rauch, Radio Telemetry, Second Edition, Appendix 8.



1. A1 = PLUG CARD
2. A2 = SWITCHING CARD
3. A3 = ELECTRONIC CARD
4. EMR DRAWING CONTROL NO. 229-004.

Figure 4-6. Output Filter, Simplified Schematic Diagram

at by an RC network (2R620 and 2C613). The DC gain of 1000 of the chopper amplifier has the effect of dividing the equivalent drift at the input of the output amplifier by 1000. Since the input stage of the output amplifier (2Q601) is a special low-drift silicon transistor, extremely stable DC operation is provided.

The DC gain of the chopper amplifier is accomplished by modulating the DC error signal by means of a shunt-type chopper, silicon transistor 2Q701. This type of chopper has the advantages of very low DC drift, long-term stability, infinite life, and high-frequency operation. The output of the chopper is a 6-Kc square wave with an amplitude proportional to the DC error signal of the output amplifier, and phase of either zero or 180 degrees depending on the polarity of the error signal. The high chopping frequency in conjunction with RC network 2R620 and 2C613 provides very low intermodulation distortion of discriminator output signals harmonically related to the chopper frequency.

The error signal is amplified by a high-gain amplifier consisting of transistors 2Q702 through 2Q706. Transistors 2Q702 and 2Q703 are connected as a high-input-impedance boot-strapped follower to provide isolation between the chopper and amplifier circuits. Further amplification of the signal is provided by 2Q704 and 2Q705. Transistor 2Q706 is used as the emitter-follower output stage of the amplifier.

The amplified AC error signal is converted back to a DC signal by a complementary synchronous detector consisting of transistors 2Q708 and 2Q709. The AC component of the detected signal is filtered by an RC network consisting of resistor 2R709 and bipolar capacitor 2C706-2C712. The 6-Kc signals driving both the chopper and synchronous detector are the outputs of an astable (free-running) multivibrator consisting of transistors 2Q710 and 2Q711. The output signals at the collectors of the multivibrator transistors are inverted square waves of magnitude 5 volts peak about ground. Diodes 2CR705 and 2CR706 ensure self-starting of the multivibrator. Adjustment of the output amplifier DC offset, contributed by the approximately 1-millivolt offset of the chopper transistor, is accomplished by feedback of a properly phased signal to the input of the AC-coupled chopper amplifier. The amplitude and phase of this signal are controlled by the output amplifier zero control, potentiometer 2R732.

3.8 Percent-Bandedge Meter

The PERCENT BANDEDGE meter located on the front panel of the Model 210A is connected at the input of the voltage-controlled oscillator. The meter has a center balance movement and, with multiplier resistor 1R214, a sensitivity of 3.0 volts for full-scale deflection. The meter scale is calibrated to $\pm 100\%$ from center. Since ± 3.0 volts at the VCO input corresponds to bandedge frequency deviation, the meter indicates percent of bandedge frequency deviation regardless of the position of the BANDEDGE VOLTS control.

3.9 Signal-Loss Circuit

When the subcarrier amplitude falls below a predetermined threshold level for a significant period of time, the signal-loss circuit energizes the SIGNAL LOSS lamp and clamps the discriminator output to ground. All circuit components of the signal loss circuit are located on the Model 210A main printed-circuit card (Figure 5-19). The output of the second limiter stage (first gain stage) is coupled by 1C301 to a feedback amplifier consisting of transistors 1Q301 and 1Q302. The amplifier output is converted to a DC signal, with amplitude proportional to signal amplitude, by a full-wave voltage-doubling rectifier consisting of diodes 1CR301 and 1CR302 and capacitors 1C302 and 1C303.

Transistors 1Q303 and 1Q304 comprise a differential-voltage comparator. When the base of 1Q303 is more negative than the base of 1Q304, transistor 1Q303 conducts, transistor 1Q304 cuts off, and the SIGNAL LOSS lamp lights. When the discriminator input amplitude is zero, 1Q303 is biased on by voltage determined by resistors 1R321 and 1R322. As the discriminator input amplitude increases, the rectified output of the feedback amplifier is an increasing positive voltage. At the input zero-signal threshold level, this positive voltage exceeds the negative bias, the voltage detector reverses states, and 1Q304 conducts. The zero-signal threshold level is set by adjusting the gain of the feedback amplifier by means of variable resistor 1R319 in the feedback network.

The voltage-detector output at the collector of transistor 1Q304 is direct coupled to the base of transistor 1Q305. Below zero-signal threshold, transistor 1Q305 conducts to saturation, clamping the loop-amplifier output, and consequently the data output, to ground. Transistor 1Q305 is emitter coupled to the zero-signal lamp driver, 1Q306. At input signal levels below zero-signal threshold, 1Q306 is driven to saturation, energizing the SIGNAL LOSS neon lamp, 4DS301, connected in the collector circuit.

The rectifier at the output of the feedback amplifier is driven by emitter follower 1Q302 which has low output impedance providing fast charging of the rectifier filter capacitors. Discharge time through the high resistance of 1R312 is slow, thereby preventing the output lamp from operating on input-signal flutter.

When loss-of-lock operation occurs, diode 1CR304 conducts applying a positive pulse to the base of transistor 1Q307. Transistors 1Q307 and 1Q308 comprise a combination monostable multivibrator and neon-lamp driver. Transistor 1Q307 is normally conducting and transistor 1Q308 is normally cut off. The pulse transmitted to the base of 1Q307 triggers the multivibrator; the output pulse at the collector of 1Q308 energizes the LOCK LOSS neon lamp (4DS302) for a duration of 500 milliseconds (refer to waveform 5). The expanded period of illumination is necessary so the occasional loss operation can be observed when it occurs at a slow rate during operation of low-frequency subcarrier channels. The SIGNAL LOSS and LOCK LOSS lamps are interlocked by 1R315 to prevent simultaneous lighting, giving a false lock-loss indication during loss of signal.

4.3.10 Lock-Loss Circuit

Circuit components of the lock-loss circuit are located on the Model 210 main printed-circuit card (Figure 5-19). The LOCK LOSS indicator lamp is located on the Model 210A front panel.

Normally, the discriminator phase-locked-loop operates with a phase error of less than $\pm 90^\circ$ between the limiter and VCO signals. When this phase error exceeds 90° , however, the phase-locked loop goes into a lock-loss condition and the LOCK LOSS indicator lamp lights.

The phase relationship between the limiter and VCO signals during normal operation of the phase-locked-loop detector are shown in Figure 4-7. Limiter output signal A (waveform 1) is coupled to the loss-of-lock circuit through follower-isolator transistor 1Q110. VCO output signal B (waveform 4) is coupled to the loss-of-lock circuit by isolator-shaper transistor 1Q201, which inverts the signal, phasing it with VCO output signal A (waveform 2). The limiter and VCO input signals to the loss-of-lock circuit are shown in Figure 4-4, waveforms 1 and 2. The VCO signal is differentiated by capacitor 1C201 and added to the limiter signal by a resistive matrix consisting of 1R115, 1R137, and 1R134. The output signal of the resistive matrix is applied to the anode of diode 1CR304 which serves as a coincidence gate (waveform 3). Since the cathode of diode 1CR304 is returned to ground through 1CR305 and the base-emitter junction of transistor 1Q307, diode 1CR304 cannot conduct unless the anode is positive with respect to ground.

When loss-of-lock operation occurs, the positive pulse transmitted by diode 1CR304 is applied to the base of transistor 1Q307. Transistors 1Q307 and 1Q308 comprise a combination monostable (one-shot) multivibrator and neon-amp driver. Transistor 1Q307 is normally conducting and transistor 1Q308 is cut off. The pulse transmitted to the base of 1Q307 triggers the multivibrator; the output pulse at the collector of 1Q308 energizes the LOCK LOSS neon amp (4DS302) for a duration of 500 milliseconds (see waveform 5). The extended period of illumination is necessary so that occasional loss-of-lock operation can be observed when it occurs at a slow rate during operation of low-frequency subcarrier channels. The SIGNAL LOSS and LOCK LOSS lamps are interlocked by means of 1R315 so that they cannot be illuminated simultaneously, giving a false loss-of-lock indication upon loss of signal.

4.3.11 Power Regulators

The Model 210A contains two power regulators for furnishing highly regulated voltage to critical circuits in the Models 210A and 229A. The regulators (one -15-volt and one +15-volt) are located on the Model 210A secondary printed-circuit card (Figure 5-21). The ± 18 -volt inputs are obtained from the Model 223G Power Supply. Operation of the two regulators are the same; therefore, only the +15-volt regulator is described in the following paragraphs.

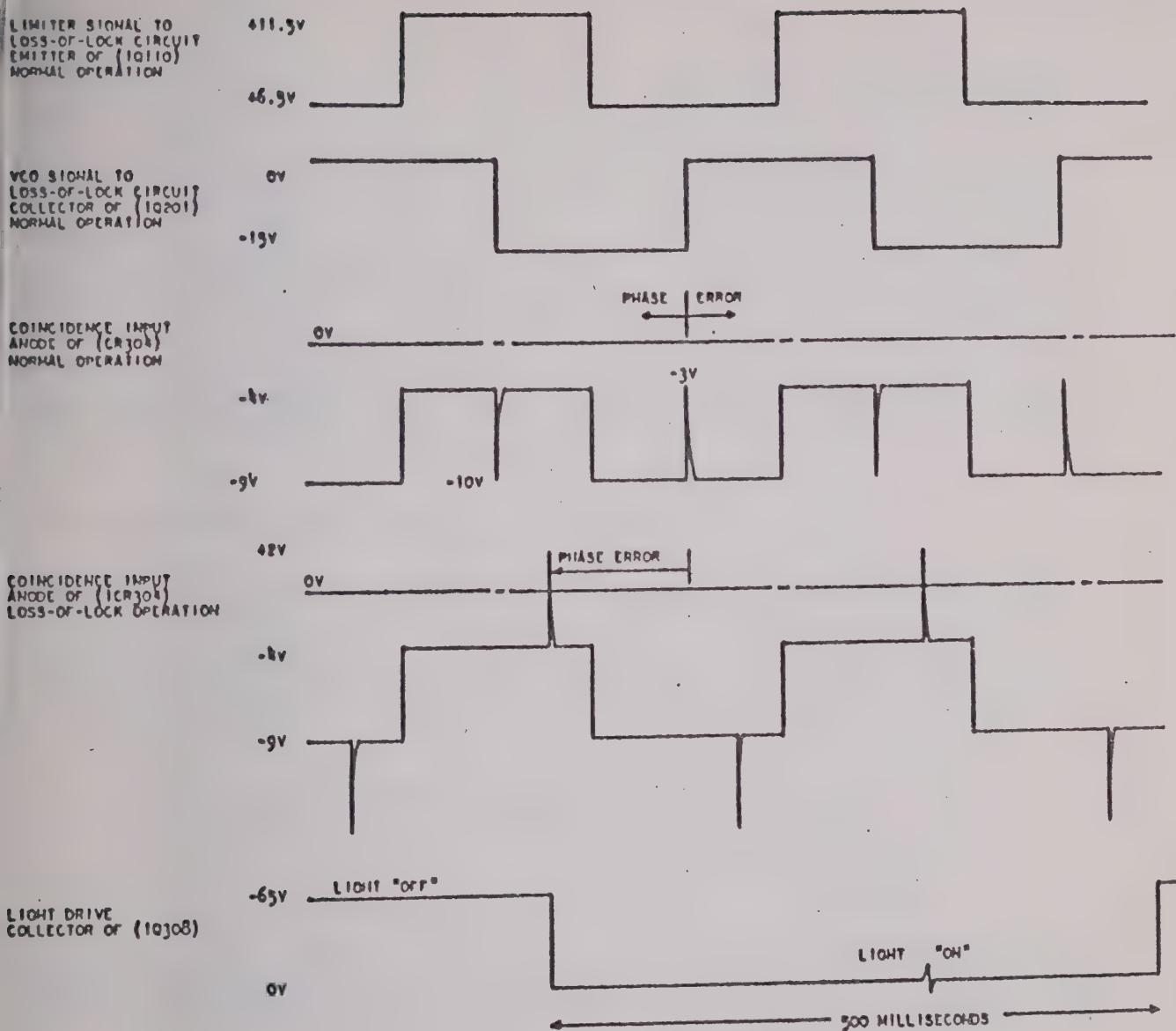
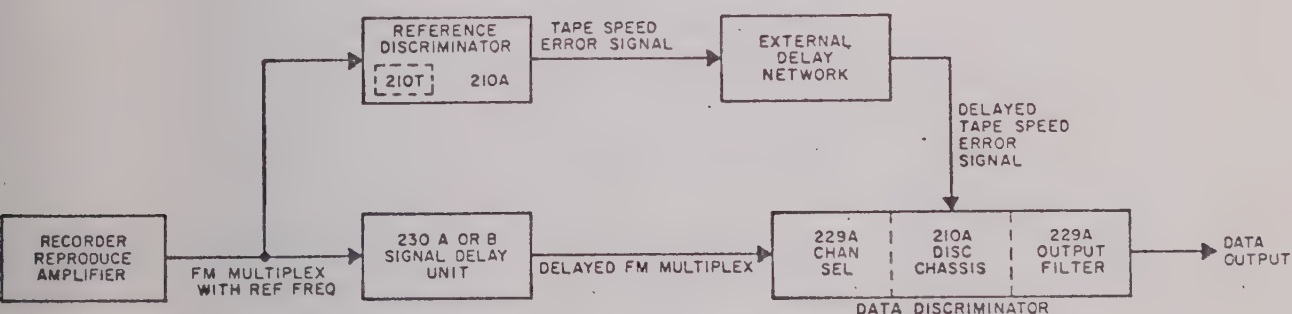


Figure 4-7. Idealized Waveforms, Lock-Loss Circuit

Transistor 2Q807 is used as a series regulating element (controlled variable resistor in series with the load). Transistor 2Q808 is Darlington connected to the series regulating transistor to reduce the current drive required. The series regulator is controlled by a differential amplifier, 2Q810 and 2Q811. The amplifier compares the regulated supply voltage to that of a precision temperature-compensated Zener reference diode, 2CR804. The high load impedance of the differential amplifier provided by constant-current generator 2Q812 provides gain in the regulator loop. The series regulator is thus controlled to provide voltage related to the reference diode voltage and is not affected by drift and ripple of the preregulated input supply. Potentiometer 2R818 in the voltage comparator permits adjustment of the regulated output to exactly 15 volts. During normal operation of the supply regulator, transistor 2Q809 does not conduct. When the output current of the regulator supply exceeds approximately 150% of its normal value, the voltage drop across series resistor 2R814 causes transistor 2Q809 to conduct and turn off the series regulator. The output current of the supply regulator is limited to 150% or less of its normal load current, thus providing short-circuit protection.

4.4 TAPE-SPEED COMPENSATION

The Model 229 Tunable Discriminator can be compensated for magnetic-tape recorder/reproducer speed changes with a system similar to that shown in Figure 4-8. This system requires a reference discriminator such as EMR Model 210A/210T, a signal delay unit such as EMR Model 230A or 230B, and an external delay network.



NOTE:

1. EMR DRAWING CONTROL NO. 229-005.

Figure 4-8. Tape-Speed Compensation, Block Diagram

A reference frequency is recorded simultaneously with the composite subcarrier signal. On playback, a reference discriminator tuned to the reference frequency introduces a correction voltage into the data discriminator to reduce effects of tape-speed changes.

The Model 230 Signal Delay Unit is used to match the delay through the reference discriminator bandpass input filter. A delay network must also be used to compensate for the time delay of the data-discriminator bandpass input filter. This

elay network is required to produce a nominal delay of 13.5° based on a signal frequency corresponding to a modulation index of 5. The exact delay may be calculated for various channels by using the following equation:

$$\text{Time delay} = \frac{0.187}{F_c D}$$

F_c = center frequency in CPS

D = % deviation ÷ 100

SECTION 5

MAINTENANCE

5.1 GENERAL

This section contains information to aid in troubleshooting and maintaining the Model 229 Tunable Discriminator. Included is a list of recommended test equipment, procedures for individual circuit tests, test-point waveforms, filter characteristic curves, transistor voltage measurements, schematics, and parts-location diagrams. If in any tests it is necessary to extend units from the rack adapter, the Model 222B Test Adapter should be used.

If a malfunction occurs, the following general method of troubleshooting, using supplementary information in this section, is recommended.

- a. Perform visual inspection (paragraph 5.2).
- b. Perform circuit tests to aid in isolating trouble to a particular circuit (paragraphs 5.3.2 through 5.3.10).
- c. Make transistor voltage measurements per Tables 5-2 and 5-3 to isolate defective components.
- d. Refer to Section 6, Parts Lists, for description of components.
- e. Recalibrate discriminator (paragraph 5.3.11).

5.2 VISUAL INSPECTION

When a malfunction occurs, the following visual inspection should be performed before making any circuit checks.

- a. Inspect all connectors and controls for signs of damage, looseness, or excessive wear.
- b. Check for loose or missing external screws.
- c. Inspect wiring for loose connections.
- d. Remove units from rack adapter and inspect printed-circuit cards and components for discoloration and other signs of overheating.

5.3 CIRCUIT PERFORMANCE TESTS

A malfunction can usually be isolated to a particular circuit by performing the circuit tests described in paragraphs 5.3.2 through 5.3.11. During these tests, when a center-frequency input signal is applied to the discriminator, the operating controls must be set up to correspond to the selected input frequency. See Section 3 for control functions.) An input signal amplitude of 1 volt RMS should be used for all tests unless otherwise specified.

5.3.1 Test Equipment Requirements

The test equipment (or equivalent) listed below is recommended for tests outlined in this section.

- a. EMR Model 217A Switchable Voltage-Controlled Oscillator
- b. Hewlett-Packard Models 204B or 200CD Test Oscillators
- c. Hewlett-Packard Model 202A Test Oscillator
- d. Berkeley Model 7360 Events Counter
- e. Hewlett-Packard Model 400L AC Voltmeter
- f. Simpson Model 260 DC Multimeter
- g. Fluke Model 801 Precision DC Voltmeter
- h. Tektronix Model 545A Oscilloscope with dual-trace and high-gain plug-in modules

5.3.2 Power Supply and Regulator Check

- a. Using precision DC voltmeter, check the following Model 223G Power Supply output voltages with any of the three GROUND test points on the power supply as reference ground.

<u>Plug P1 on Power Supply</u>	<u>DC Voltage</u>
pin B	+18
pin V	-18
pin W	-24
pin A	-100

- b. Using oscilloscope and precision DC voltmeter, check the ± 15 -volt regulator voltage at test points TP2 (+15V, red) and TP5 (-15V, yellow). (See Figure 5-1.) These voltages should be within ± 75 millivolts. If necessary, adjust supply with +15V ADJ and -15V ADJ controls. The 120 CPS ripple at the test points should not exceed 5 millivolts peak-to-peak during normal operation. The appropriate power supply manual should be consulted if the unit is found to be defective.

5.3.3 Bandpass Input Filter (BPIF) Gain and Frequency Characteristics Test

- a. With a constant-amplitude subcarrier input to the Model 229, measure BPIF output amplitude at INPUT test point using the AC voltmeter. Insertion loss of BPIF at bandcenter should be nominally 6 Db. The gain should be down 2.5 Db at either bandedge compared to maximum gain in the band. A BPIF characteristic curve is shown in Figure 5-3.
- b. Vary subcarrier input center frequency by $\pm 20\%$. Gain should be down greater than 10 Db for $\pm 7.5\%$ deviation setting.
- c. Vary subcarrier input center frequency by $\pm 40\%$. Gain should be down greater than 10 Db for $\pm 15\%$ deviation setting.

5.3.4 Limiter Gain and Frequency Characteristics

- a. Remove the Model 229A Tunable Channel Selector/Output Filter from rack adapter.
- b. Using test oscillator, apply a signal to INPUT test point on the Model 210A Discriminator Chassis front panel.
- c. Using oscilloscope and AC voltmeter, monitor limiter output at test point TP3 LIM. (See Figure 5-1.) Adjust input-signal amplitude until limiter output signal is a maximum-amplitude sinewave with no limiting action (approximately 1 volt RMS). Limiter gain should be approximately 2000 with -4-Db frequencies of 50 CPS and 500 Kc.
- d. To check limiting, vary input-signal amplitude between 5 millivolts RMS and 5 volts RMS. The limiter output signal should vary from a clipped sinewave to a squarewave of approximately 5 volts peak-to-peak amplitude. (See waveform 1, Figure 5-2.)
- e. Replace Model 229A Tunable Channel Selector/Output Filter in rack adapter before proceeding to next test.

5.3.5 Phase-Locked-Loop Detector Test

- a. Apply an unmodulated center-frequency input signal to the discriminator. The limiter, VCO, and loop-amplifier output voltages and waveforms at test points TP3 (white), TP4 (green), and TP6 (blue) should be as shown in waveforms 1, 2, and 3 of Figure 5-2. The average DC voltage at the loop-amplifier output test point (TP6) should be zero with the input signal frequency at bandcenter by adjusting BALANCE control on the Model 229A. This voltage should be +3 volts with input signal at upper bandedge and -3 volts at lower bandedge.
- b. With an unmodulated center-frequency input signal to discriminator, limiter output signal monitored at TP3, and VCO output signal monitored at TP4 should be squarewaves displaced in phase by 90 degrees, as shown in waveforms 1 and 2 of Figure 5-2. The phase displacement can be measured accurately by using the dual-trace plug-in and calibrated delayed-sweep controls of the oscilloscope or the start and stop inputs of the events counter. With BALANCE control adjusted for zero volt at TP6, the phase displacement between limiter and VCO voltage signals should be 90 ± 2 degrees. If phase displacement is not within these limits, adjust PHASE BAL control. With input-signal frequency at bandedges, phase displacement should be 90 ± 4 degrees.
- c. Apply a modulated input signal to the discriminator from the switchable VCO. The waveform at loop amplifier output TP6 should be as shown in waveform 4 of Figure 5-2. The loop amplifier waveform is modulation signal with superimposed ripple at second harmonic of subcarrier frequency. The second-harmonic ripple frequency is attenuated by discriminator output filter to provide a distortionless data-output signal.
- d. Using HP202A, modulate switchable VCO, bandedge-to-bandedge, with a squarewave of approximately one-fifth the output filter cutoff frequency. Set OUTPUT RESPONSE switch to CD and LOOPWIDTH switch to 1. The LOCK LOSS lamp should not light and discriminator output should be a squarewave with limited rise time. With sinusoidal bandedge-to-bandedge modulation at frequencies equivalent to the modulation frequencies for deviation ratios of 5, 10, 25, 50, and 100, LOCK LOSS should not light and discriminator output signal should be an undistorted sinewave with LOOPWIDTH switch in the corresponding positions.

5.3.6 Output Filter Output Amplifier Test

- a. Disconnect jumper between test pins ES and EW on the main printed-circuit card assembly in the Model 210A and inject a signal from test oscillator to pin EW. Gain and frequency characteristics of the output filter are measured at the OUTPUT test point. With BANDEDGE VOLTS control at maximum, do not exceed an output voltage of 7 volts RMS or an input voltage of 2.33 volts RMS. At frequencies less than one-fifth of output-filter cutoff frequency, gain of output amplifier should be $1/3$ with BANDEDGE VOLTS control at minimum and $3-1/3$ with BANDEDGE VOLTS control at maximum. With this control at maximum, the output voltage is limited to approximately -12.5 volts to +12.5 volts. Theoretical output filter characteristics are shown in Figure 5-4. Reconnect jumper between pins ES and EW on main printed-circuit card.
- b. Apply an unmodulated center-frequency input signal to discriminator. Using precision DC voltmeter to monitor OUTPUT test point, adjust OUT AMP ZERO control on the Model 210A Discriminator Chassis to 0 ± 10 millivolts.

NOTE

The output amplifier is a feedback amplifier with additional gain in the loop provided at DC and low frequencies by the chopper amplifier. Because of the extremely high overall gain, the amplifier cannot be operated open loop and troubleshooting may be difficult. When the output filter and power amplifier circuit are operating properly, the voltage at the negative connection of 2C706 should be 0 ± 100 millivolts DC (use the precision DC voltmeter for this measurement). If these voltage limits are exceeded, operation of the output filter and power amplifier may be checked without the chopper amplifier by connecting the junction of 2R606 and 2C604 to the junction of 2R621 and 2R627, and connecting the negative connection of 2C706 to ground.

5.3.7 Signal Loss Lamp Check

With an unmodulated center-frequency input signal, SIGNAL LOSS lamp should light at approximately 5 millivolts input-signal amplitude as input signal amplitude is reduced. When SIGNAL LOSS lamp is on, discriminator output voltage should be 0 ± 1 volt with the BANDEDGE VOLTS control at maximum. The

input level at which SIGNAL LOSS light and clamp operate can be adjusted by means of the ZERO SIG THRESH control.

5.3.8 Lock Loss Lamp Check

Operation of the LOCK LOSS lamp can be checked by overdeviating the subcarrier input signal at maximum modulation frequency defined by deviation ratio of channel selector.

5.3.9 Percent Bandedge Meter Check

By adjusting BALANCE control, PERCENT BANDEDGE meter, 4M201, should read 100% L, 0, and 100% U for lower bandedge, bandcenter, and upper bandedge subcarrier input signals, respectively.

5.3.10 VCO Oven Controller Check

Proper operation of the VCO oven controller is checked by monitoring supply current at pin W of rear connector 1P1. When controller is operating properly, this current will be approximately 125 Ma at initial turn on of the discriminator. The current will decrease to approximately 70 Ma after 15 minutes operation; at this time, the oven temperature should stabilize to approximately 65°C. If any VCO oven-controller components are replaced, readjust operating temperature by varying the value of 3R505. A thermocouple attached to the inner can of an assembled oven may be used for the temperature measurement.

5.3.11 Discriminator Output Calibration Linearity

- a. Apply an unmodulated center-frequency input to the discriminator with amplitude between the minimum specified input level and 5 volts RMS. Adjust BALANCE control for zero volt at OUTPUT test point.
- b. Set input signal frequency to upper bandedge. Voltage at OUTPUT test point should be -10 volts $\pm 3\%$ with BANDEDGE VOLTS control fully clockwise and -1 volt $\pm 3\%$ with BANDEDGE VOLTS control fully counterclockwise.
- c. Set input signal frequency to lower bandedge. Voltage at OUTPUT test point should be +10 volts $\pm 3\%$ with BANDEDGE VOLTS control fully clockwise and -1 volt $\pm 3\%$ with BANDEDGE VOLTS control fully counterclockwise.

3.12 External Zero Offset

The DC offset at the discriminator data output can be varied externally as shown in Figure 5-5. To simplify connections to the discriminator rear connector (1P1), provisions for external zero offset control must be added by field or factory modification. The modification consists of the addition of resistor 2R653 to the secondary card assembly and connection of a wire jumper from 2R653 to pin K of connector 1P1. The type and values of resistor 2R653 are listed in Section 6, Parts Lists. Mounting provisions are provided on the printed-circuit-card assembly. When the external zero offset modification is installed, a 10-volt signal at pin K of 1P1 will cause an output DC offset of 10% of bandwidth and the sensitivity polarity is negative. After installation of the modification, pin K of 1P1 should be connected to signal ground, pin N of 1P1, when external zero offset control is not used.

3.13 External Gain

The sensitivity of the discriminator can be varied externally, as shown in Figure 5-5. To simplify connections to the discriminator rear connector (1P1), provisions for external gain control must be added by field or factory modification. To perform the modification, disconnect the wire jumper connected between the junction 4R636 and 2R648 (on the main printed-circuit-card assembly) and pin Y of connector 1J2. Install a jumper from the junction of 4R636 and 2R648 to pin S of 1P1 and a jumper between pin Y of 1J2 and pin T of 1P1.

External components required for remote gain control are a 500-ohm precision potentiometer and a 2000-ohm $\pm 1\%$ resistor (IRC type MEA-T0 or equivalent). Varying the external gain control from its midvalue (250 ohms) to its extremes varies the output amplifier gain and the discriminator sensitivity by $\pm 10\%$, regardless of the position of the BANDEDGE VOLTS control, 4R636. In order that the calibration of the BANDEDGE VOLTS control be accurate (refer to Section 2, paragraph 2.1.1, Output Voltage and Current), the value of 2R648 should be changed from 100 ohms $\pm 1\%$ to 105 ohms $\pm 1\%$; the calibration is then accurate with the external gain control set for minimum sensitivity (the wiper of the external gain control potentiometer at the end connected to pin S of 1P1). When the external gain control is at its midvalue, the calibration of the BANDEDGE VOLTS control is 10% too low. When the external gain control is used for calibration purposes, the voltage at pin S of 1P1 is -1.10 volts at high bandedge and +1.10 volts at low bandedge, with the external gain control in its midposition.

NOTE

The leads for connecting the external gain control should be low-capacity shielded cable. The total capacitance of each cable should be less than 1000 Pf.

4 CALIBRATION CHECK

Although the calibration can be checked by various methods, a three-point check should be sufficient. With the discriminator first adjusted for zero output at center frequency, the outputs at the two bandedges should differ by less than .1% of full bandwidth, indicating a maximum error of 0.05% or less. It is of prime importance that the calibration frequencies be accurately determined and that the output-voltage measuring device be extremely accurate so that this degree of precision can be achieved.

5 TROUBLESHOOTING

The performance tests as outlined in paragraph 5.3 will isolate most discriminator malfunctions to a functional circuit. Thereafter, isolation of malfunctions is performed with reference to schematic diagrams and component-location diagrams. (See Figures 5-6 through 5-28.)

Make all AC and DC voltage measurements with signal ground as reference (the three ground test points on the front panel of the Model 223G Power Supply and the discriminator ground test point, TP1, are all signal ground). Test points and adjustments are located at the top of the Model 210A Discriminator Chassis as shown in Figure 5-1 and defined in tabular form in Table 5-1. Access to the test points can be achieved by the use of two Model 222B Test Adapters. Test-point waveforms and voltages are given in Figure 5-2 and Table 5-2.

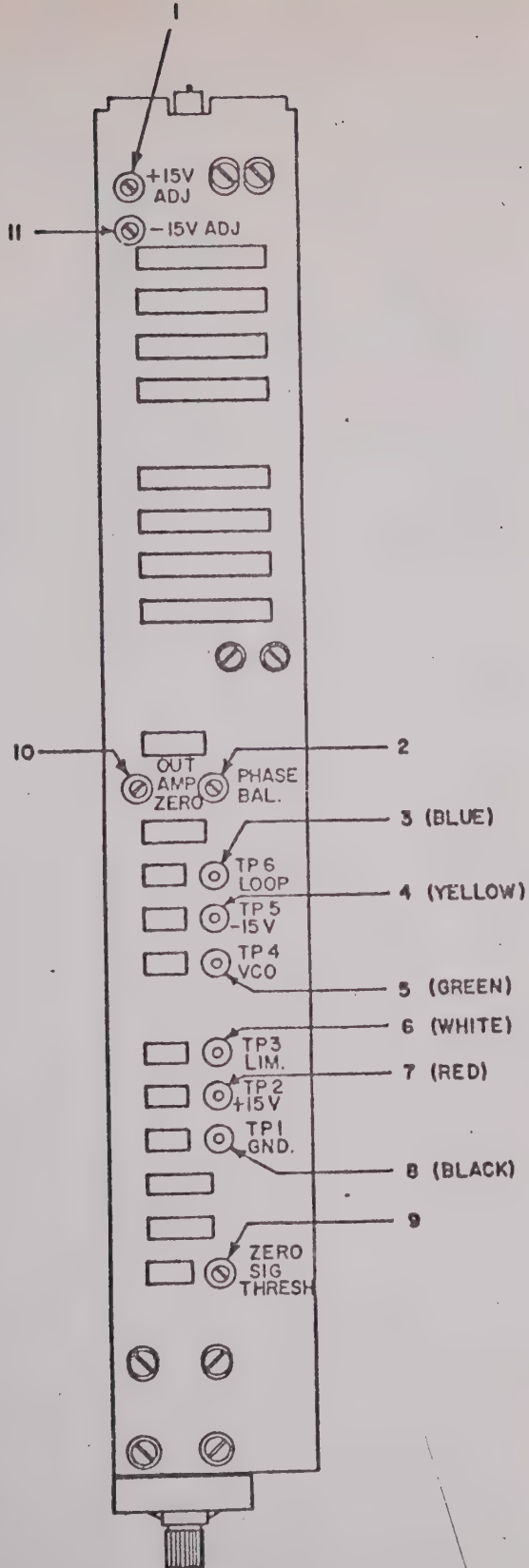


Figure 5-1. Model 210A Discriminator Chassis,
Test Points and Adjustments

Table 5-1. Model 210A Discriminator Chassis,
Location of Test Points and Adjustments

REF. NO.	NAME	DESIG- NATION	TYPE	FUNCTION
	+15V ADJ	2R818	250-ohm potentiometer	Used to adjust +15V regulator.
2	PHASE BAL.	1R240	500-ohm potentiometer	Used to adjust phase detector.
3	TP6 LOOP	TP6	Blue TP jack	Used to monitor loop output.
4	TP5 -15V	TP5	Yellow TP jack	Used to monitor -15V regulator.
5	TP4 VCO	TP4	Green TP jack	Used to monitor VCO.
6	TP3 LIM	TP3	White TP jack	Used to monitor limiter.
7	TP2 +15V	TP2	Red TP jack	Used to monitor +15V regulator.
8	TP1 GND	TP1	Black TP jack	Used as ground reference for testing.
	ZERO SIG THRESH	1R319	50K potentiometer	Used to adjust minimum input level.
0	OUT AMP ZERO	2R732	500-ohm potentiometer	Used to zero output amplifier.
1	-15V ADJ	2R807	250-ohm potentiometer	Used to adjust -15V regulator.

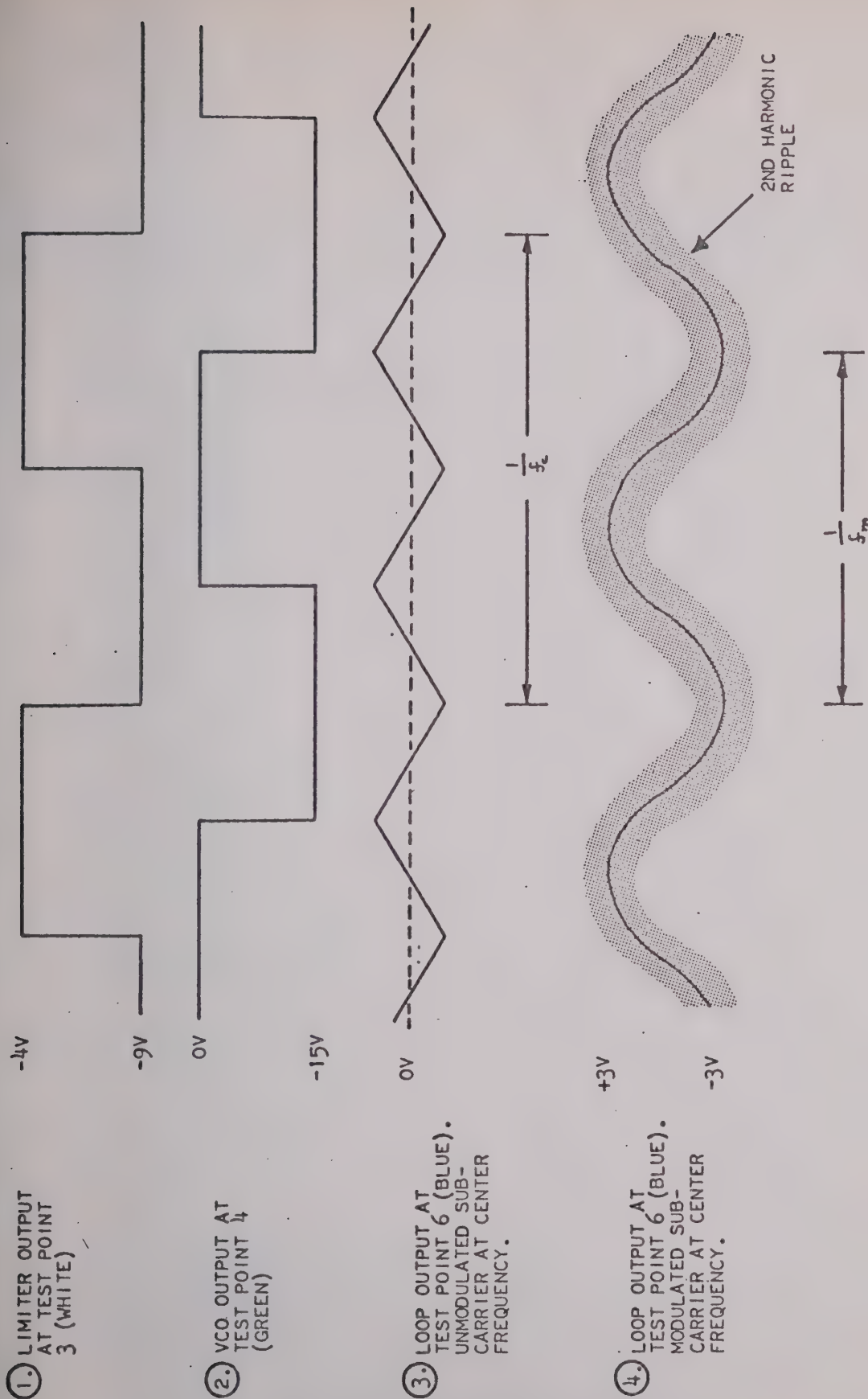


Figure 5-2. Waveforms at Test Points

Table 5-2. Model 229A Electronic Printed-Circuit Card A3,
Transistor Voltages

TRAN- SISTOR	BASE	EMITTER	COL.	TRAN- SISTOR	BASE	EMITTER	COL.
Q1	-10.0V	-11.0V	0 $\pm$ 2	Q14	0 $\pm$ 2	0 $\pm$ 2	-10.0
Q2	-10.0	-11.0	0 $\pm$ 2	Q15	0 $\pm$ 2	0 $\pm$ 2	-10.0
Q3	-10.0	-11.0	0 $\pm$ 2	Q16	+7.2	+7.5	0 $\pm$ 2
Q4	-10.0	-11.0	0 $\pm$ 2	Q17	+11.5V	+11.8V	0 $\pm$ 2
Q5	0 $\pm$ 2	0 $\pm$ 2	-8.0	Q18	+11.0	+11.0	0 $\pm$ 2
Q6	-10.0	-11.0	0 $\pm$ 2	Q19	+11.5	+11.8	0 $\pm$ 2
Q7	+11.2	+11.5	-15.0	Q20	-9.0	-10.0	0 $\pm$ 2
Q8	0 $\pm$ 2	0 $\pm$ 2	-8.0	Q21	-9.0	-10.0	0 $\pm$ 2
Q9	-10.0	-11.0	0 $\pm$ 2	Q22	-9.0	-10.0	0 $\pm$ 2
Q10	+11.2	+11.5	-15.0	Q23	-9.0	-10.0	0 $\pm$ 2
Q11	0 $\pm$ 2	0 $\pm$ 2	+15.0	Q24	0 $\pm$ 2	0 $\pm$ 2	-9.0
Q12	0 $\pm$ 2	0 $\pm$ 2	-10.0	Q25	0 $\pm$ 2	0 $\pm$ 2	-9.0
Q13	0 $\pm$ 2	0 $\pm$ 2	-10.0	Q26	0 $\pm$ 2	0 $\pm$ 2	-9.0
				Q27	0 $\pm$ 2	0 $\pm$ 2	-9.0

NOTES:

1. Voltage measurements made with VTVM.
2. Voltages should be within ± 1 volt unless otherwise noted.
3. Voltage measurements made with subcarrier input grounded.

Table 5-3. Model 210A Discriminator Chassis, Transistor Voltages

TRAN- SISTOR	BASE	EMITTER	COL.	TRAN- SISTOR	BASE	EMITTER	COL.
1Q301	-0.3V	GND	-8.8V	1Q201	-0.05V	GND	-7.6V
1Q302	-8.8	-8.6	-15.0	1Q202	-9.0	-9.2	-0.4
1Q303	+20.0	+11.6	GND	1Q203	-0.38	-0.25	-15.0
1Q304	+11.4	+11.6	+11.8	1Q204	-0.25	-0.1	-13.5
1Q305	+11.8	+0.15	-0.4	1Q205	-9.2	-7.4	GND
1Q306	+0.15	GND	-64.0	1Q206	+9.3	-7.4	GND
1Q307	-0.27	GND	-0.12	1Q207	-9.1	-7.4	-0.4
1Q308	-5.7	GND	-14.9	1Q208	-9.3	-7.4	GND
1Q309	+2.5	GND	+0.25	1Q209	-7.2	-7.4	-0.4
1Q401	-0.85	GND	+4.0	1Q210	-9.2	-7.4	GND
1Q402	-0.88	GND	+4.1	1Q211	+0.42	+0.27	+13.3
1Q104	+0.46	+0.6	-5.1	2Q601	+0.26	-0.36	GND
1Q105	+0.6	+0.76	-5.1	2Q602	-0.36	-0.24	-7.6
1Q106	-0.23	GND	-7.8	2Q603	-7.6	-7.5	-13.0
1Q107	-7.8	-7.5	-15.0	2Q604	-14.0	-14.2	-4.8
1Q108	-0.23	GND	-7.2	2Q605	-14.2	-14.2	-0.5
1Q109	-7.2	-7.0	-15.0	2Q606	-0.5	-0.37	-14.4
1Q110	+9.3	+9.5	GND	2Q607	-0.3	-0.1	-14.7
1Q111	-7.0	-7.2	-7.2	2Q608	-14.7	-14.8	-0.27

Table 5-3 (Cont'd.). Model 210A Discriminator Chassis, Transistor Voltages

TRAN- SISTOR	BASE	EMITTER	COL.	TRAN- SISTOR	BASE	EMITTER	COL.
2Q609	-0.27V	-0.28V	-18.0V	2Q804	-9.0V	-8.8V	-15.0V
2Q610	+14.4	+14.7	-0.12	2Q805	-17.5	-17.8	-15.8
2Q611	-0.12	-0.22	+14.7	2Q806	-9.1	-8.8	-15.8
2Q612	-0.3	-0.4	+14.8	2Q807	+15.5	+16.0	+18.0
2Q613	+14.8	+15.0	-0.27	2Q808	+15.8	+15.5	+18.0
2Q614	-0.27	-0.27	+18.0	2Q809	+14.8	+15.0	+15.8
2Q701	-0.3	0	GND	2Q810	+9.0	+8.8	+15.0
2Q702	-0.24V	-0.12	-13.2	2Q811	+9.1	+8.8	+15.8
2Q703	-0.12	-0.02	-7.0	2Q812	+17.5	+17.8	+15.8
2Q704	-7.0	-6.8	GND	Oven Controller with Temperature Maximum			
2Q705	-0.1	-0.02	-6.4	3Q501	-1.5V	-1.3V	-1.2V
2Q706	-9.9	-10.0	-0.26	3Q502	-1.2	-1.4	-15.0
2Q708	+1.9	GND	+0.1	3Q503	-15.0	-15.0	-5.0
2Q709	-1.8	GND	+0.1	3Q504	-15.0	-14.5	-24.0
2Q710	+6.2	+4.3	-0.08	Oven Controller With Oven OFF			
2Q711	+5.9	+4.3	+0.14	3Q501	-0.5V	-0.5V	-2.15V
2Q801	-15.5	-16.0	-18.0	3Q502	-2.15	-1.8	-1.7
2Q802	-15.8	-15.5	-18.0	3Q503	-1.7	-2.1	-15.0
2Q803	-14.8	-15.0	-15.8	3Q504	-2.1	-1.75	-24.0

Table 5-3 (Cont'd.). Model 210A Discriminator Chassis, Transistor Voltages

Transistor	Base	Emitter	Collector
3Q405	-15.5V	-15.0V	-13.0V
3Q406	-15.5	-15.0	-13.0
3Q407	-10.5	-11.5	GND
5Q101	0.0	+0.15	-8.5
5Q102	+0.32	+0.32	-14.0
5Q103	+0.85	+0.52	+14.0
5Q403	-7.62	-7.58	-15
5Q404	-0.18	GND	-7.62
Inverting Amplifier at Band Center			
7Q901	0.6	-0.6	+8.1
7Q902	0.0	-0.6	+8.1
7Q903	+8.1	+8.7	-13.6
7Q904	+8.1	+8.7	+0.3
7Q905	+0.3	0.0	+15
7Q906	-0.3	0.0	-15



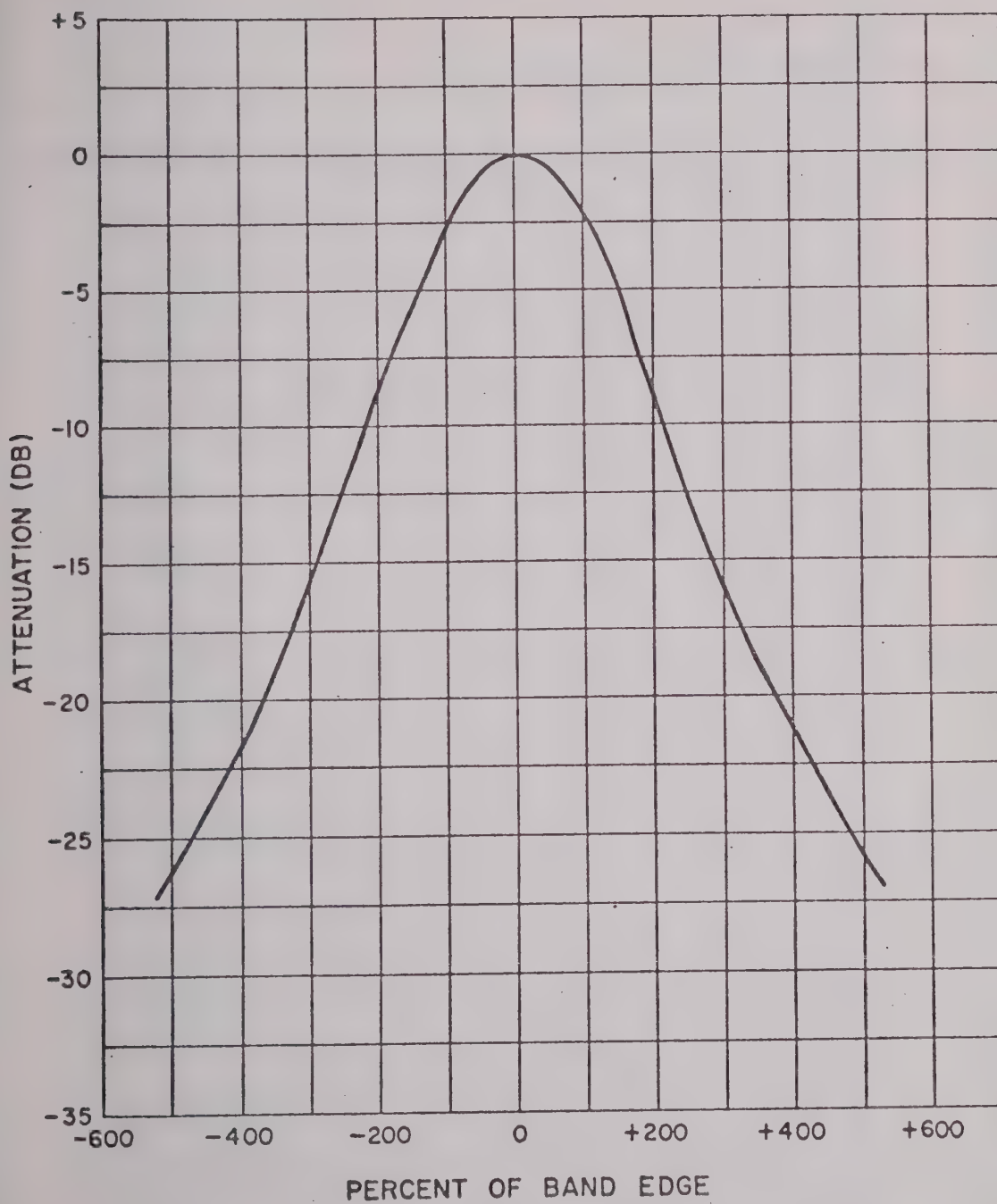


Figure 5-3. Bandpass Input Filter Characteristic Curve

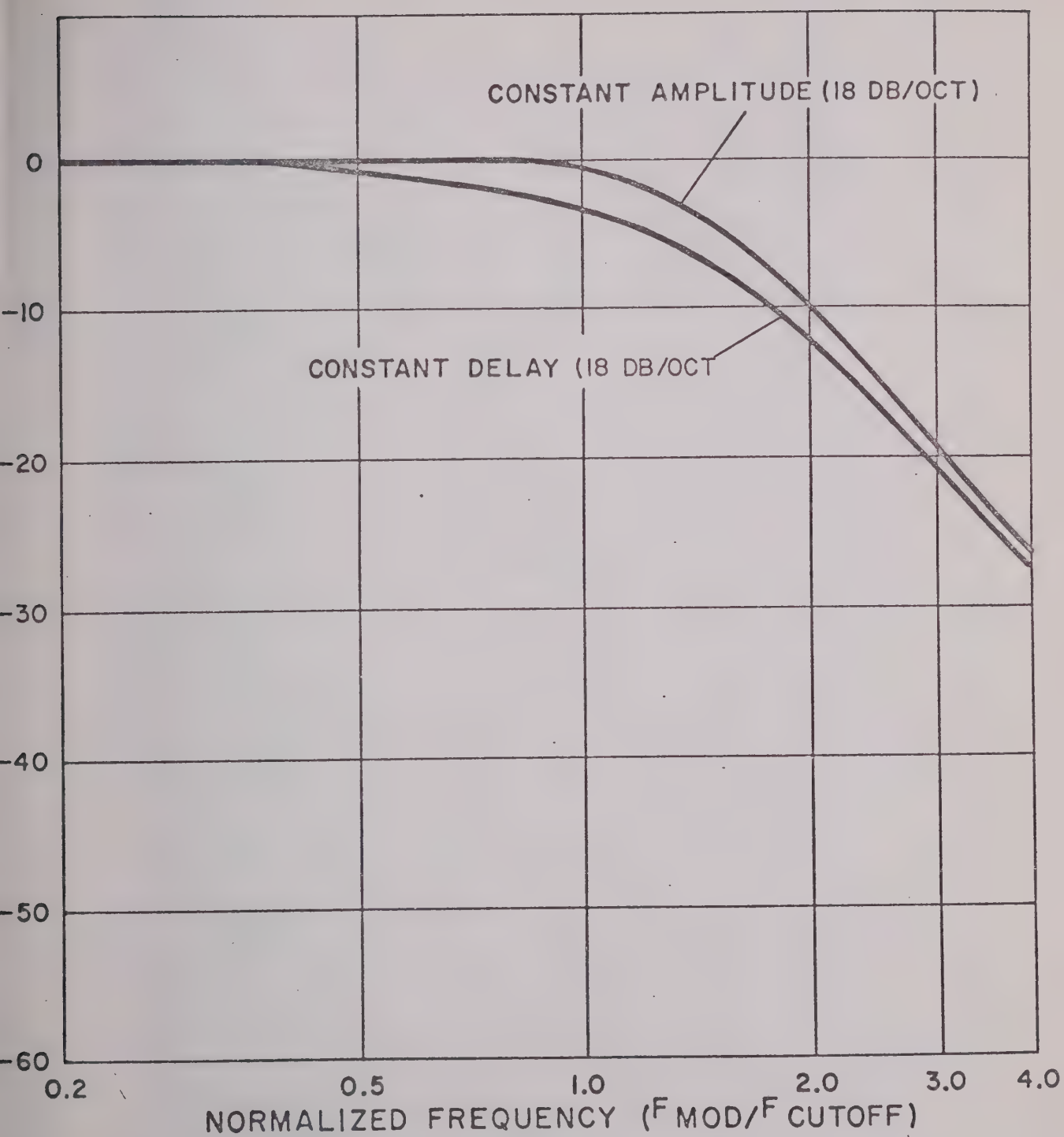
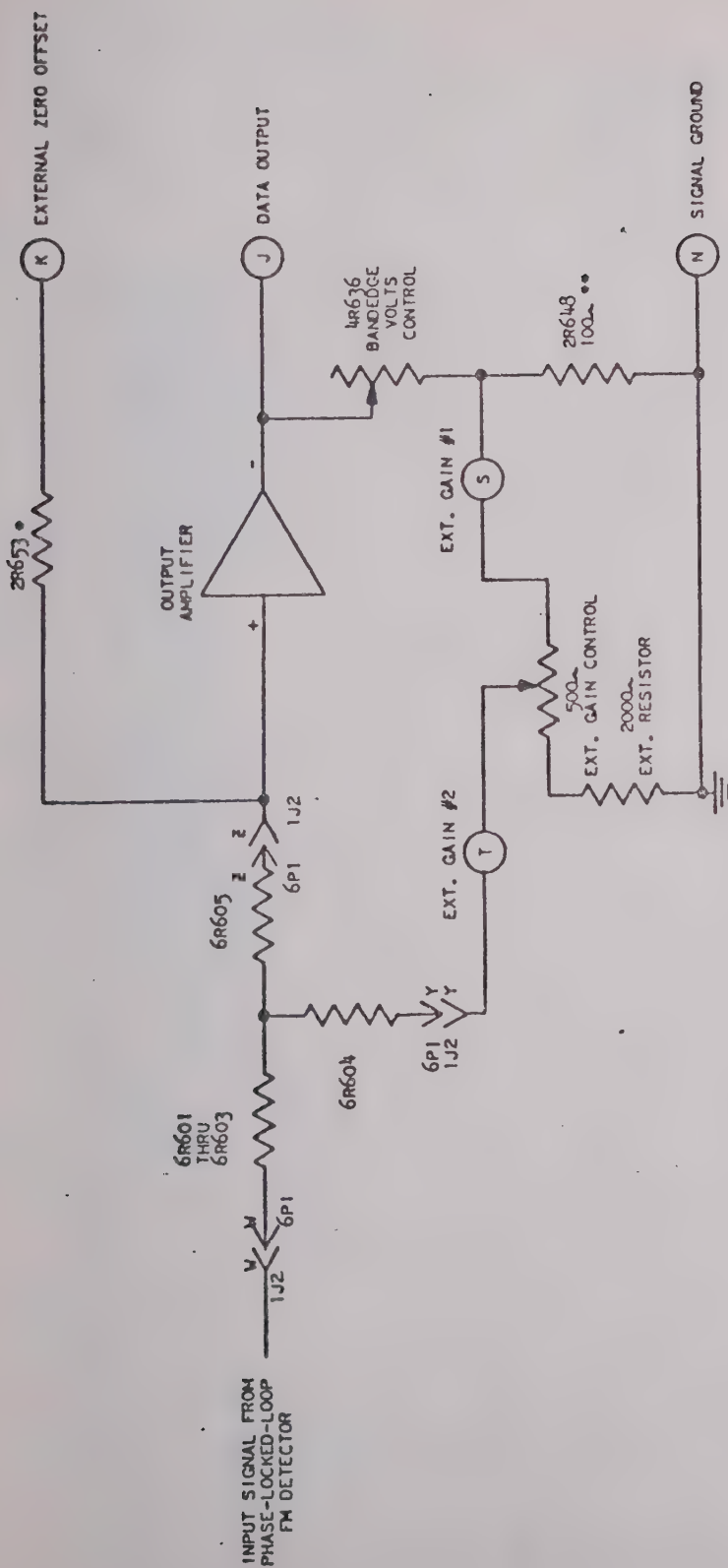


Figure 5-4. Theoretical Output Filter Response

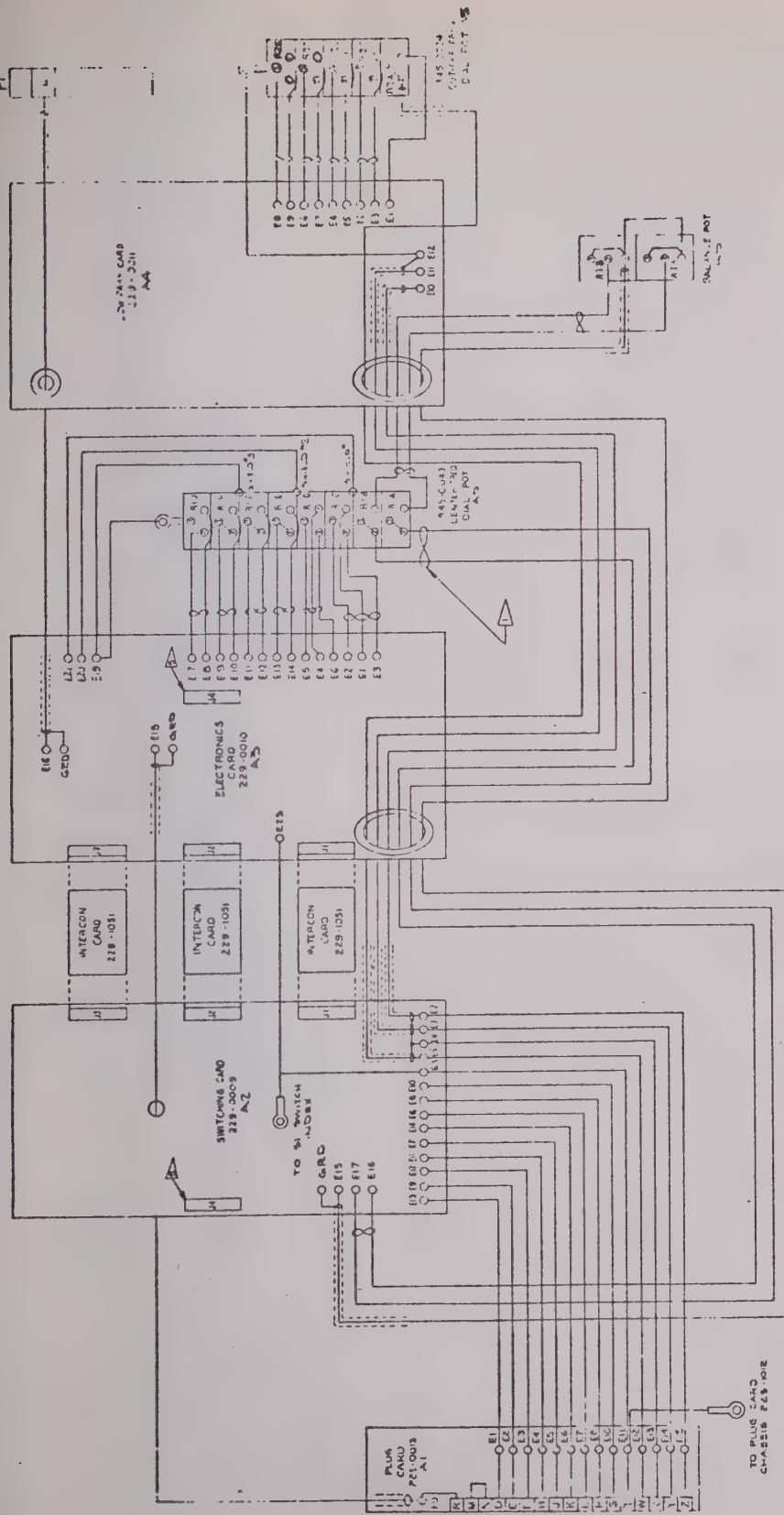


NOTES:

(X) INDICATES PIN DESIGNATION OF CONNECTOR (1P1)

- TYPE AND VALUES LISTED IN SECTION 6
- 100Ω ±1% INSTALLED, MODIFY TO 105Ω ±1% FOR PROPER OPERATION OF BANDWIDTH VOLTS CONTROL

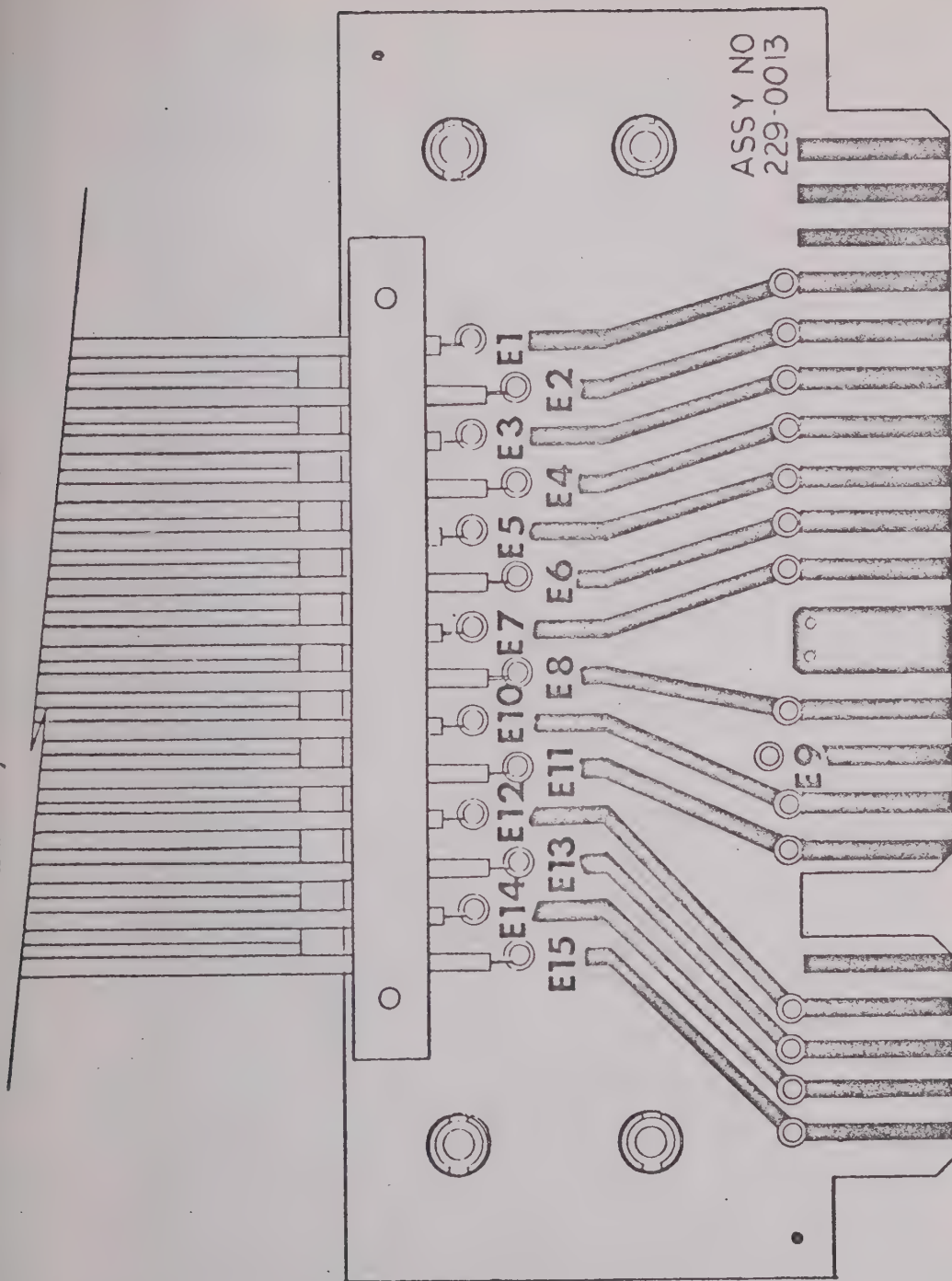
Figure 5-5. External Zero Offset and Gain Controls, Schematic Diagram



NOTE:
 1. THESE WIRES TO BE INDIVIDUALLY TWISTED AS NOTED.
 2. ALL WIRES TO BE ROUTED AS SHOWN AND MADE AS SHORT AS POSSIBLE.
 3. IN WIRE TO BE ROUTED AS SHOWN AND MADE AS SHORT AS POSSIBLE.
 4. AS TO BE REFERENCE DESIGNATION FOR FRONT PANEL.
 5. FOR USE ON MODEL 229A-01 ONLY.
 6. SEE DRAWING NO. 229-1031.

Figure 5-6. Models 229A-01 and 229A-02 Tunable Channel Selector/Output Filter, Wiring Diagram

Directly Wired to Model 229A

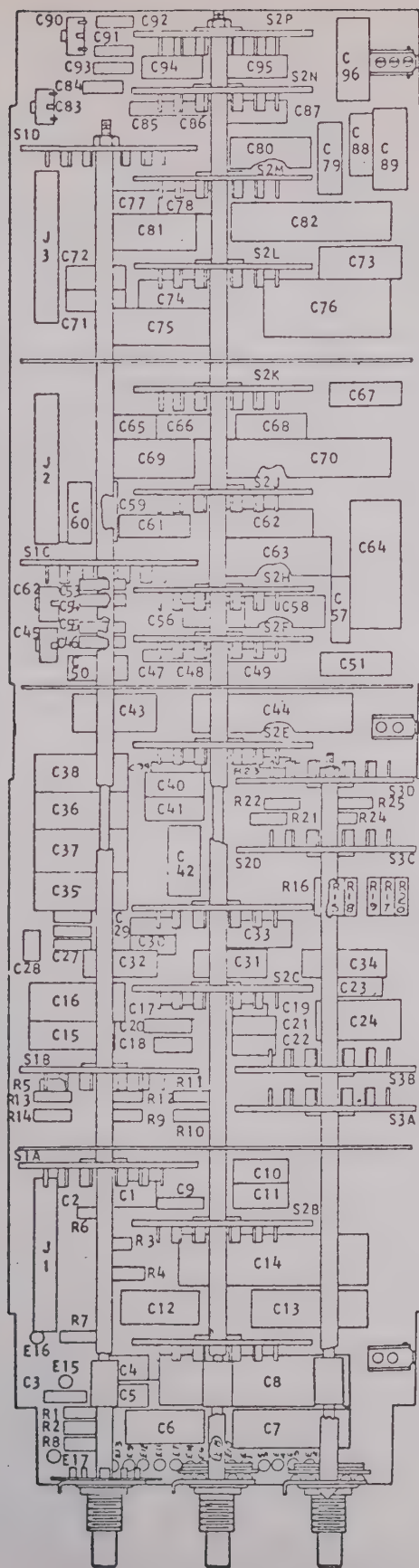


To Model 210A - 1J2

Note:

1. EMR Drawing No. 229-0013.

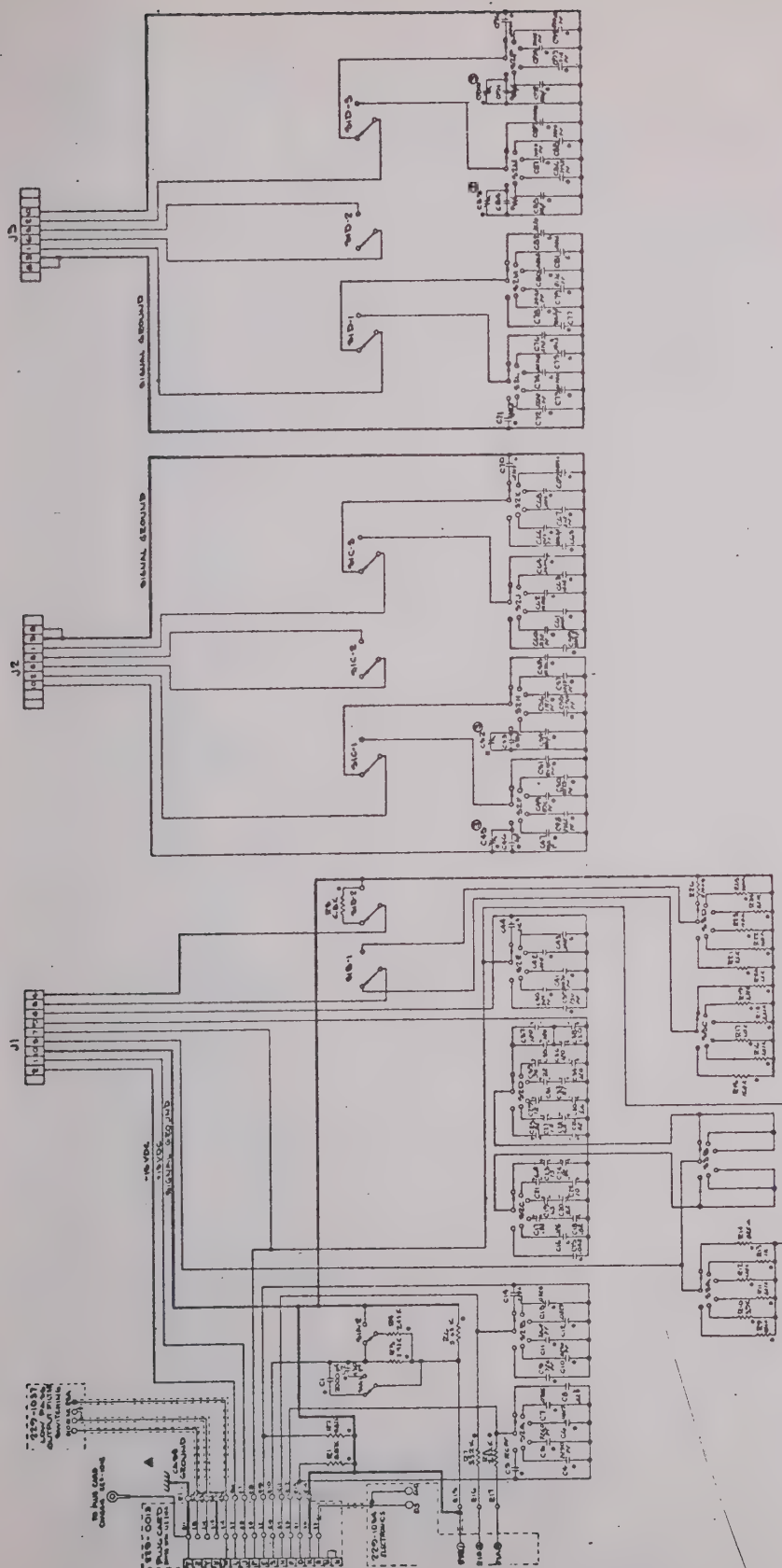
Figure 5-7. Models 229A-01 and 229A-02 Plug Card Assembly A1



Note:

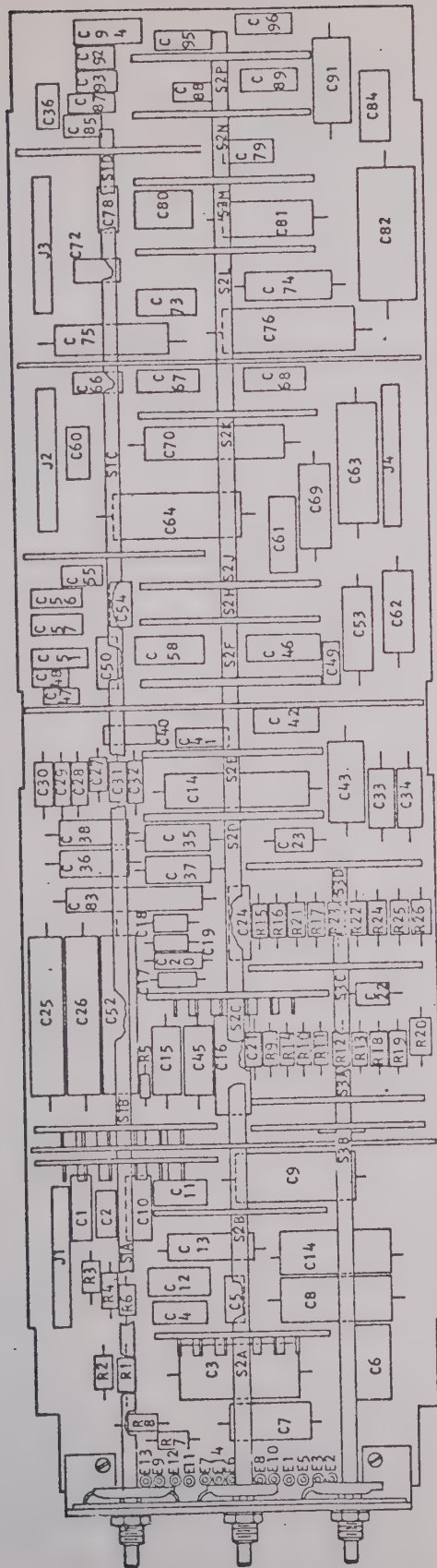
1. EMR Drawing Control No. 229-008.

Figure 5-8. Model 229A-01 Switching Printed-Circuit Card A2,
Component Location Diagram



1. ADD DIMENSION LINES AND ALL DIMENSIONS (UNLESS OTHERWISE NOTED).
 2. DIMENSIONS ARE IN INCHES (UNLESS OTHERWISE NOTED).
 3. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 4. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 5. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 6. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 7. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 8. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 9. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.
 10. DIMENSIONS ARE TO CENTER UNLESS OTHERWISE NOTED.

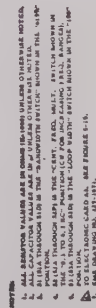
Figure 5-9. Model 229A-01 Switching Printed-Circuit Card A2, Schematic Diagram



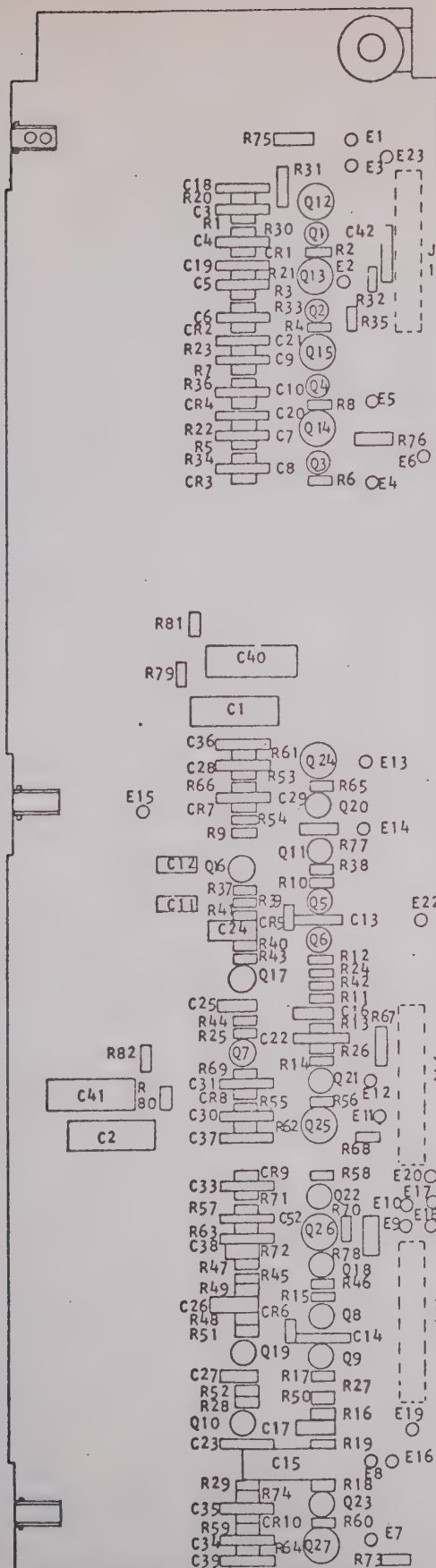
Note:

1. EMR Drawing Control No. 229-011.

Figure 5-10. Model 229A-02 Switching Printed-Circuit Card A2, Component Location Diagram



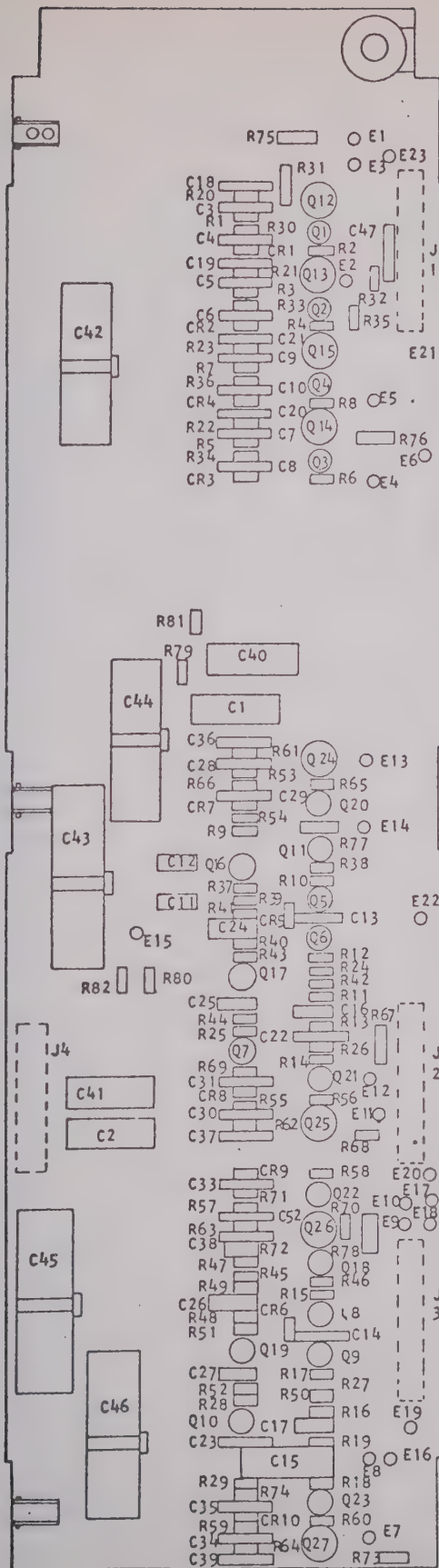
5-24.



Note:

1. EMR Drawing Control No. 229-009.

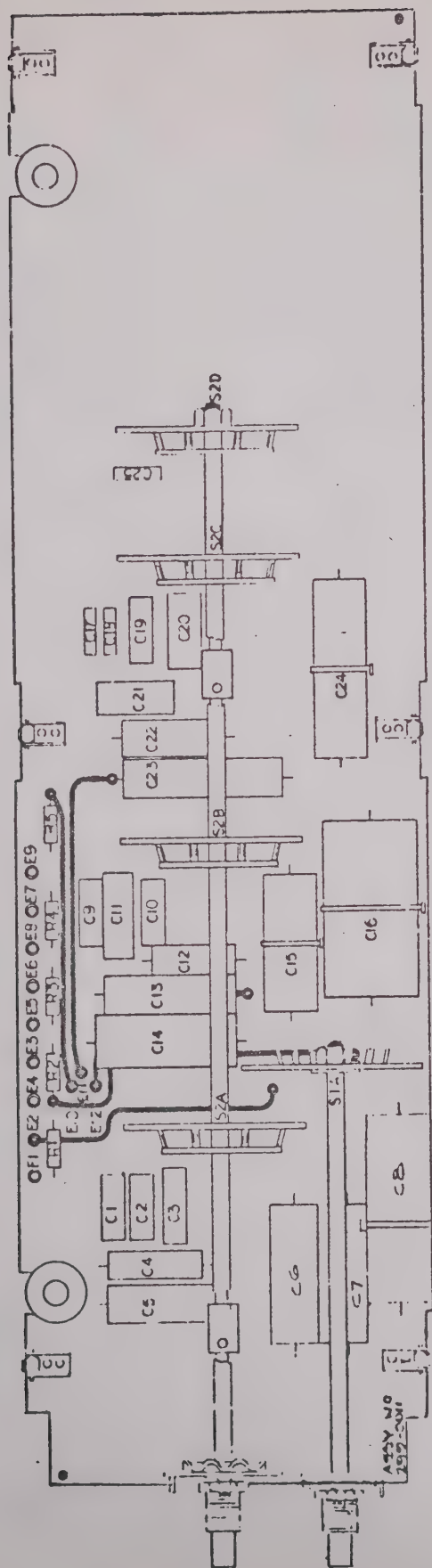
Figure 5-12. Model 229A-01 Electronic Printed-Circuit Card A3,
Component Location Diagram



Note:

1. EMR Drawing Control No. 229-010.

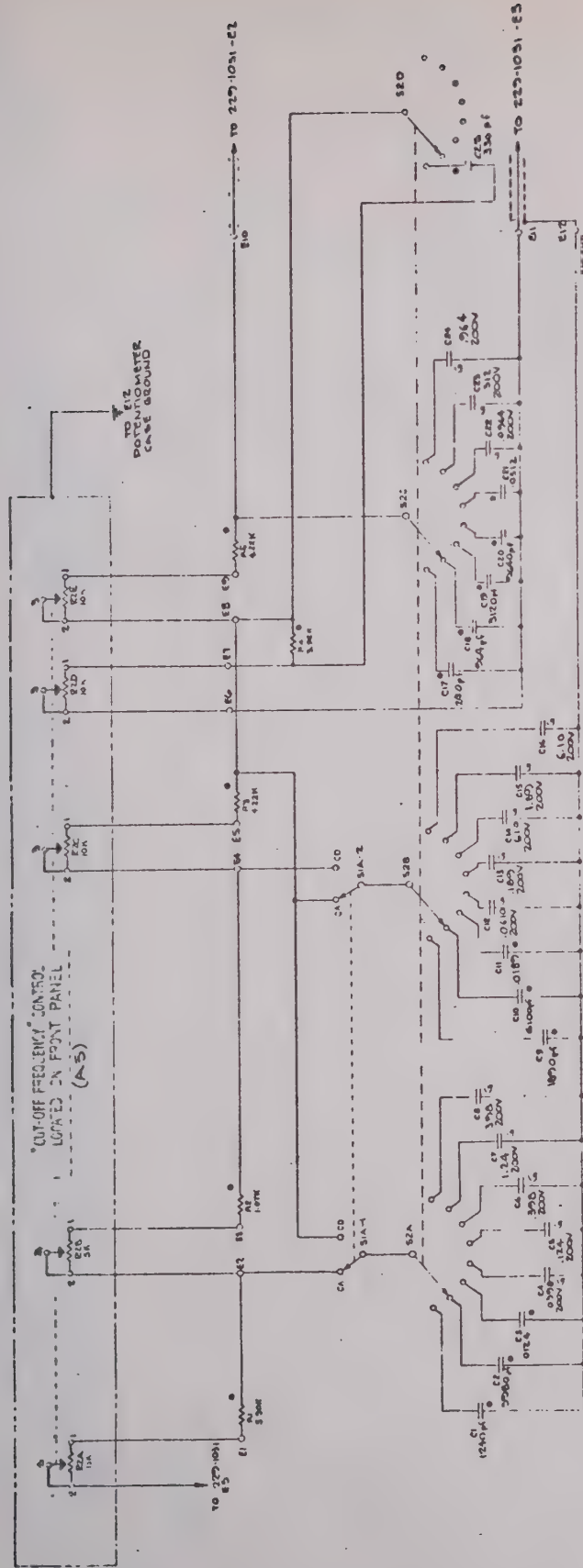
Figure 5-14. Model 229A-02 Electronic Printed-Circuit Card A3,
Component Location Diagram



Note:

1. EMR Dwg. No. 229-0011.

Figure 5-16. Models 229A-01 and 229A-02 Low-Pass Output Filter
Printed-Circuit Card A4, Component Locations



Notes:

1. All resistor values are in ohms (K=1000) unless otherwise noted.
2. All capacitor values are in $\mu\text{f} \pm 2\%$, 100V unless otherwise noted.
3. S2 (S2A through S2D) is the "CUTOFF FREQ. MULT." switch.
4. EMR Drawing No. 229-1037.

Figure 5-17. Models 229A-01 and 229A-02 Low Pass Output Filter Printed-Circuit Card A4, Schematic Diagram

Figure 5-18. Model 210A Main Printed-Circuit Card, Component Locations

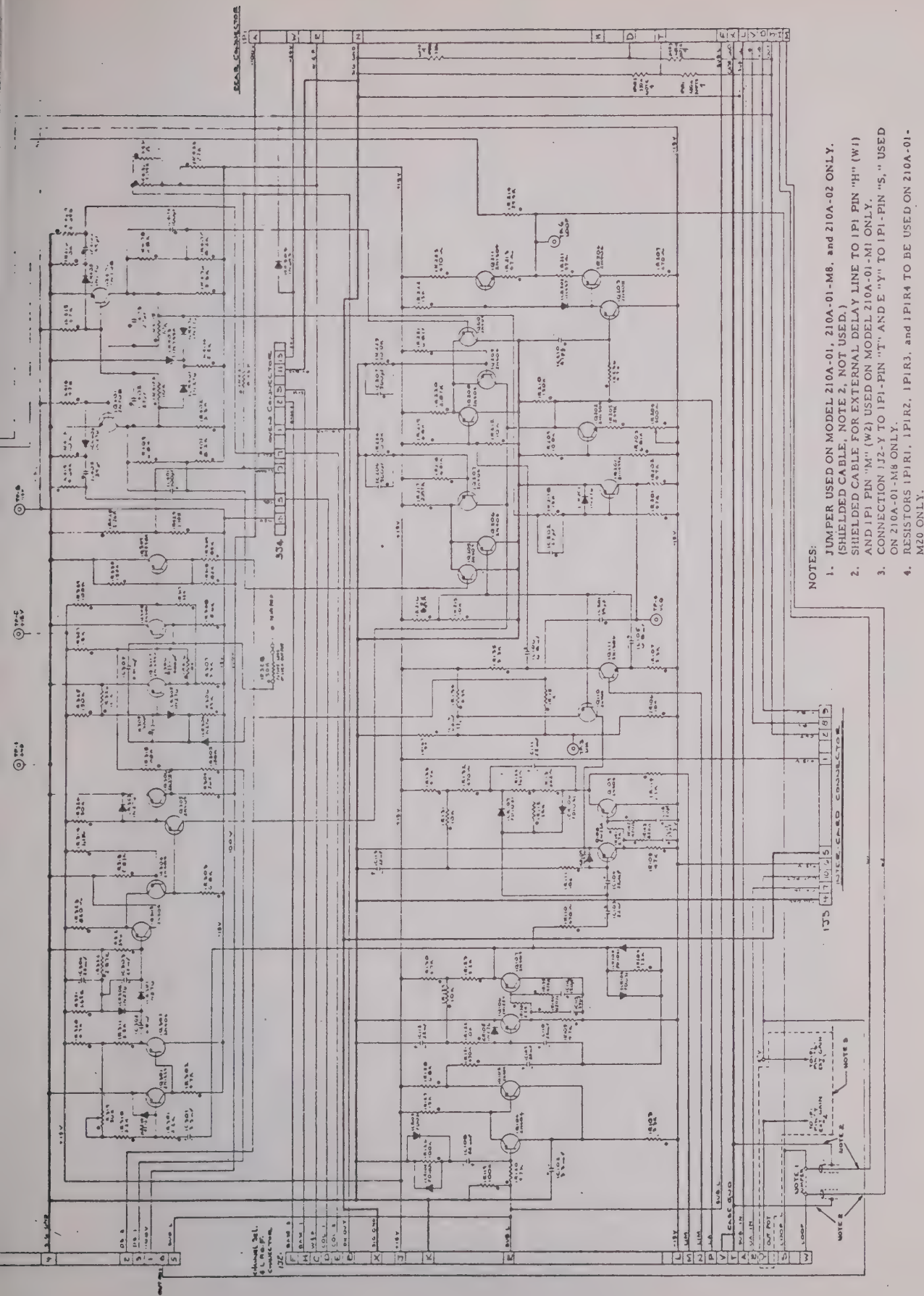
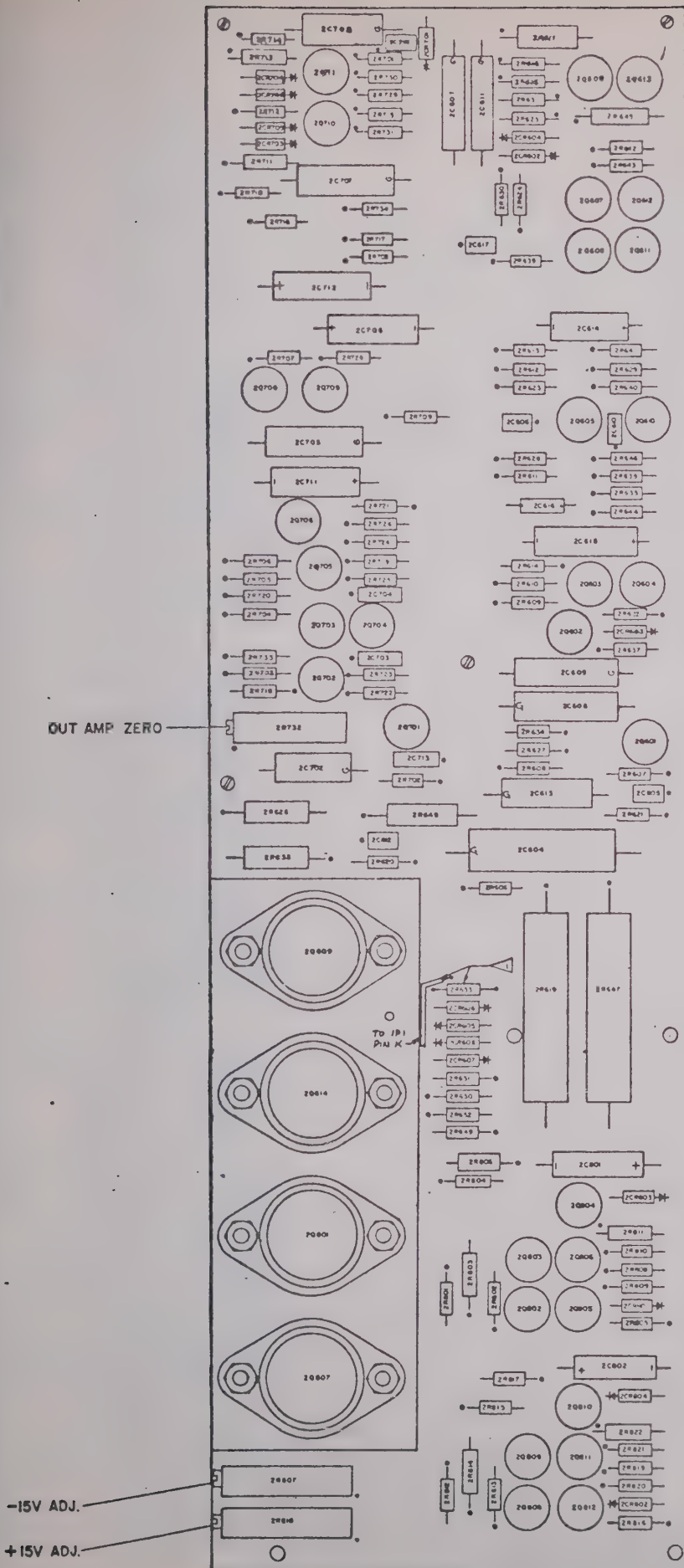


Figure 5-19. Model 210A Main Printed-Circuit Card, Schematic Diagram

FRONT



Notes:

1. To external zero (1P1 pin "K") used on 210A-01-M8 only.
2. EMR Dwg. No. 210-0012.

Figure 5-20. Model 210A Secondary Printed-Circuit Card
Component Location Diagram

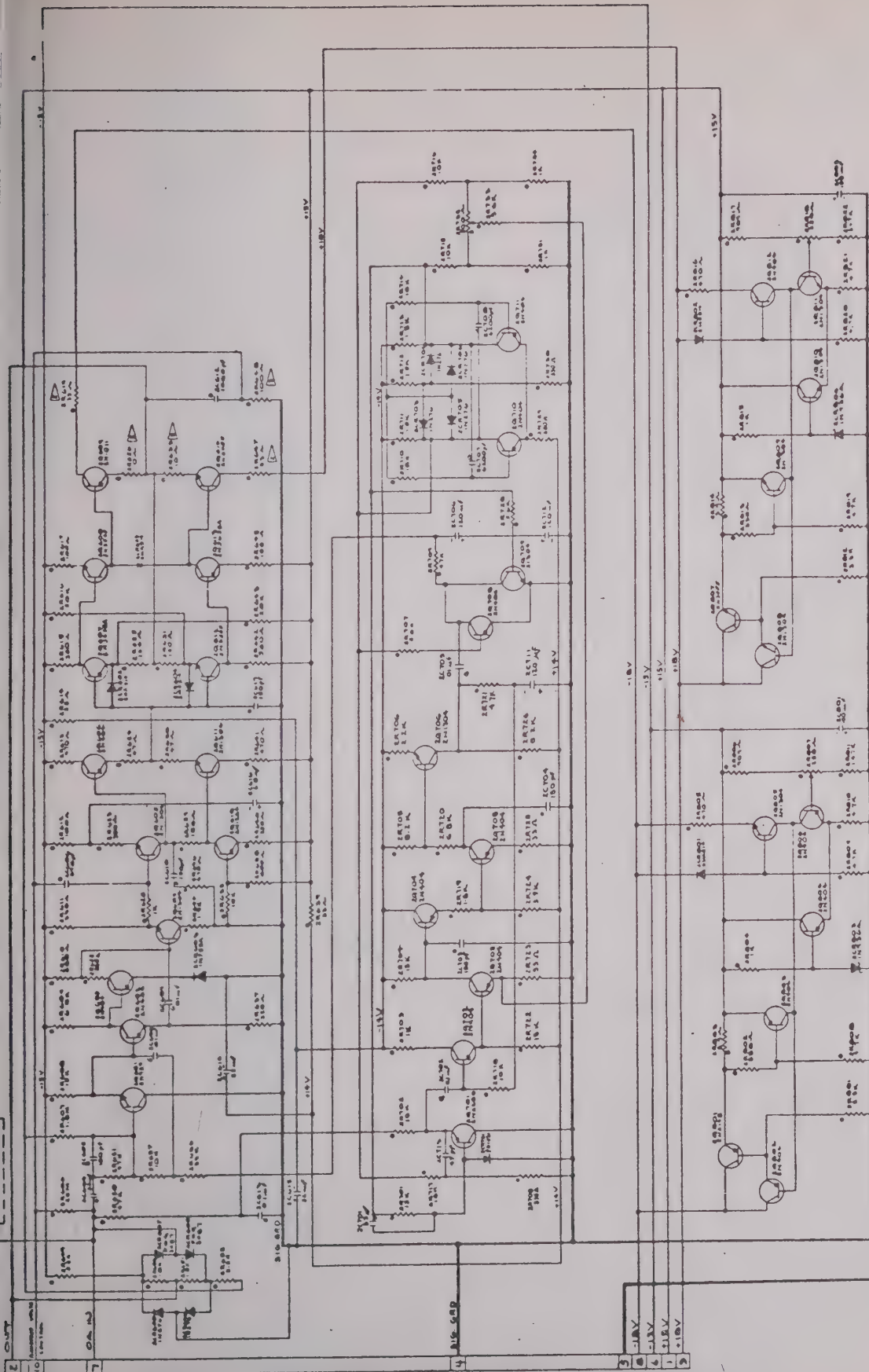
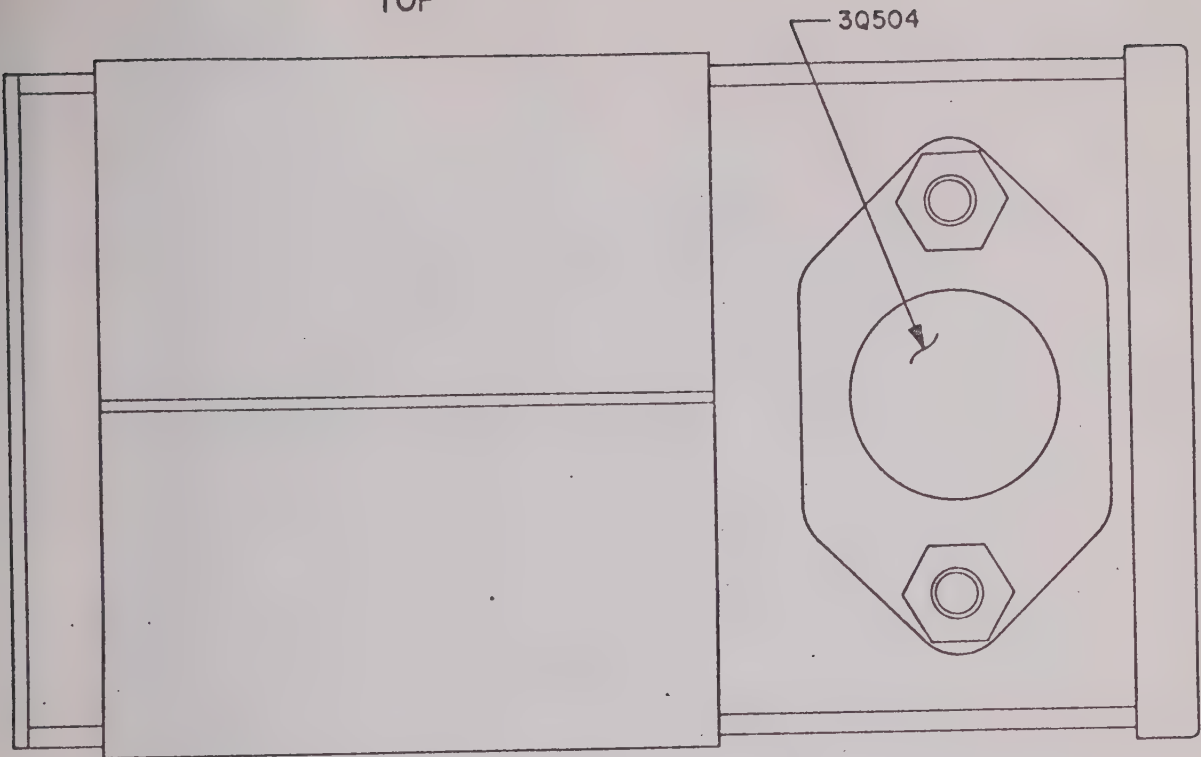


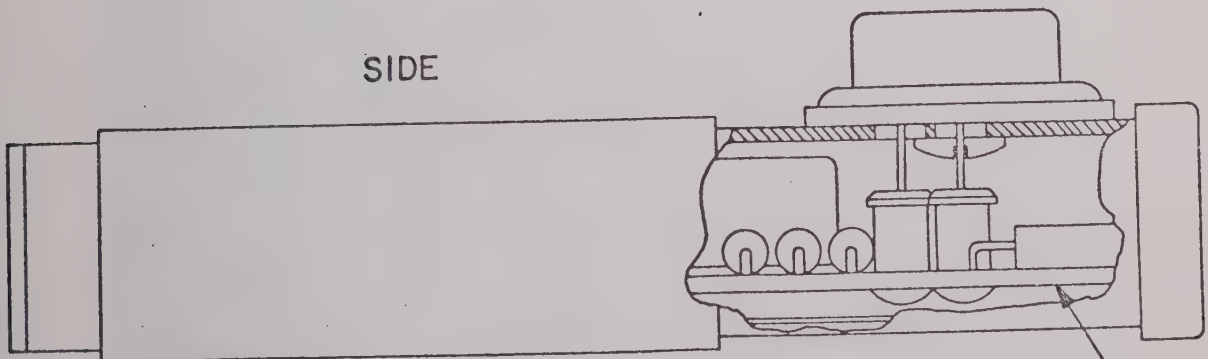
Figure 5-21. Model 210A Secondary Printed-Circuit Card, Schematic Diagram

1. 6X4, 6AR5, 6AV6, 6BD6, 6BE6, 6BE7, 6BE8, 6BE9, 6BE10, 6BE11, 6BE12, 6BE13, 6BE14, 6BE15, 6BE16, 6BE17, 6BE18, 6BE19, 6BE20, 6BE21, 6BE22, 6BE23, 6BE24, 6BE25, 6BE26, 6BE27, 6BE28, 6BE29, 6BE30, 6BE31, 6BE32, 6BE33, 6BE34, 6BE35, 6BE36, 6BE37, 6BE38, 6BE39, 6BE40, 6BE41, 6BE42, 6BE43, 6BE44, 6BE45, 6BE46, 6BE47, 6BE48, 6BE49, 6BE50, 6BE51, 6BE52, 6BE53, 6BE54, 6BE55, 6BE56, 6BE57, 6BE58, 6BE59, 6BE60, 6BE61, 6BE62, 6BE63, 6BE64, 6BE65, 6BE66, 6BE67, 6BE68, 6BE69, 6BE70, 6BE71, 6BE72, 6BE73, 6BE74, 6BE75, 6BE76, 6BE77, 6BE78, 6BE79, 6BE80, 6BE81, 6BE82, 6BE83, 6BE84, 6BE85, 6BE86, 6BE87, 6BE88, 6BE89, 6BE90, 6BE91, 6BE92, 6BE93, 6BE94, 6BE95, 6BE96, 6BE97, 6BE98, 6BE99, 6BE100.

TOP



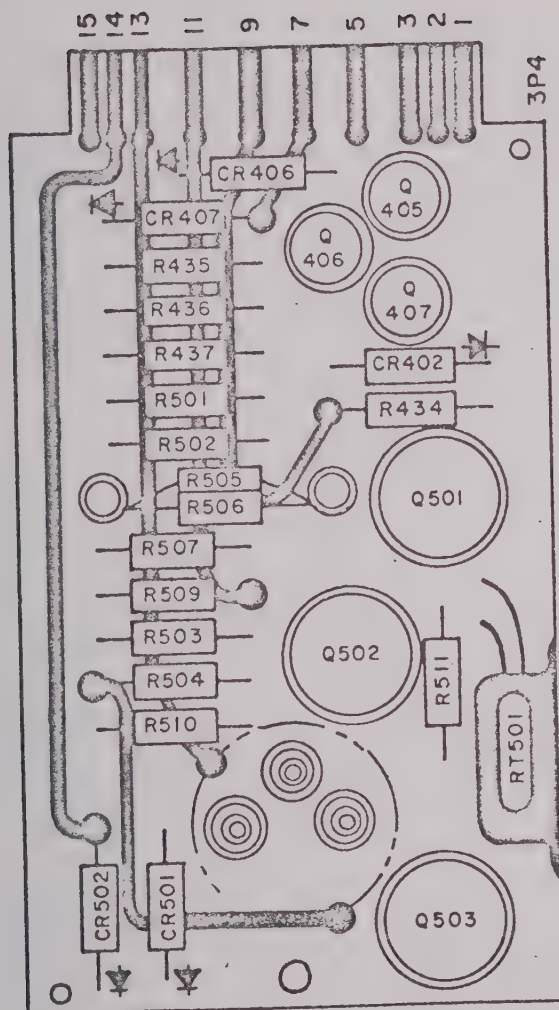
SIDE



NOTE:
EMR DRAWING CONTROL NO. 210-010.

CARD ASSEMBLY
(SEE FIG. 5-23)

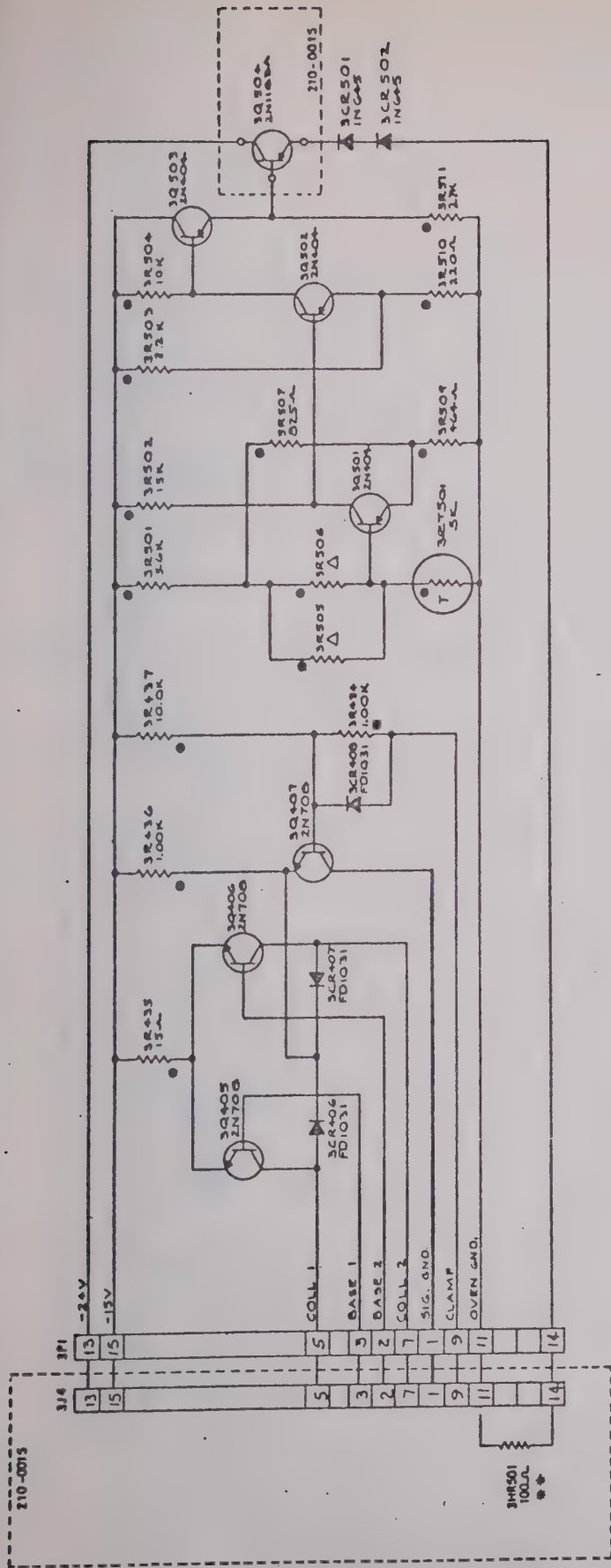
Figure 5-22. Model 210A Oven Assembly



ote:

1. EMR Dwg. No. 210-0013.

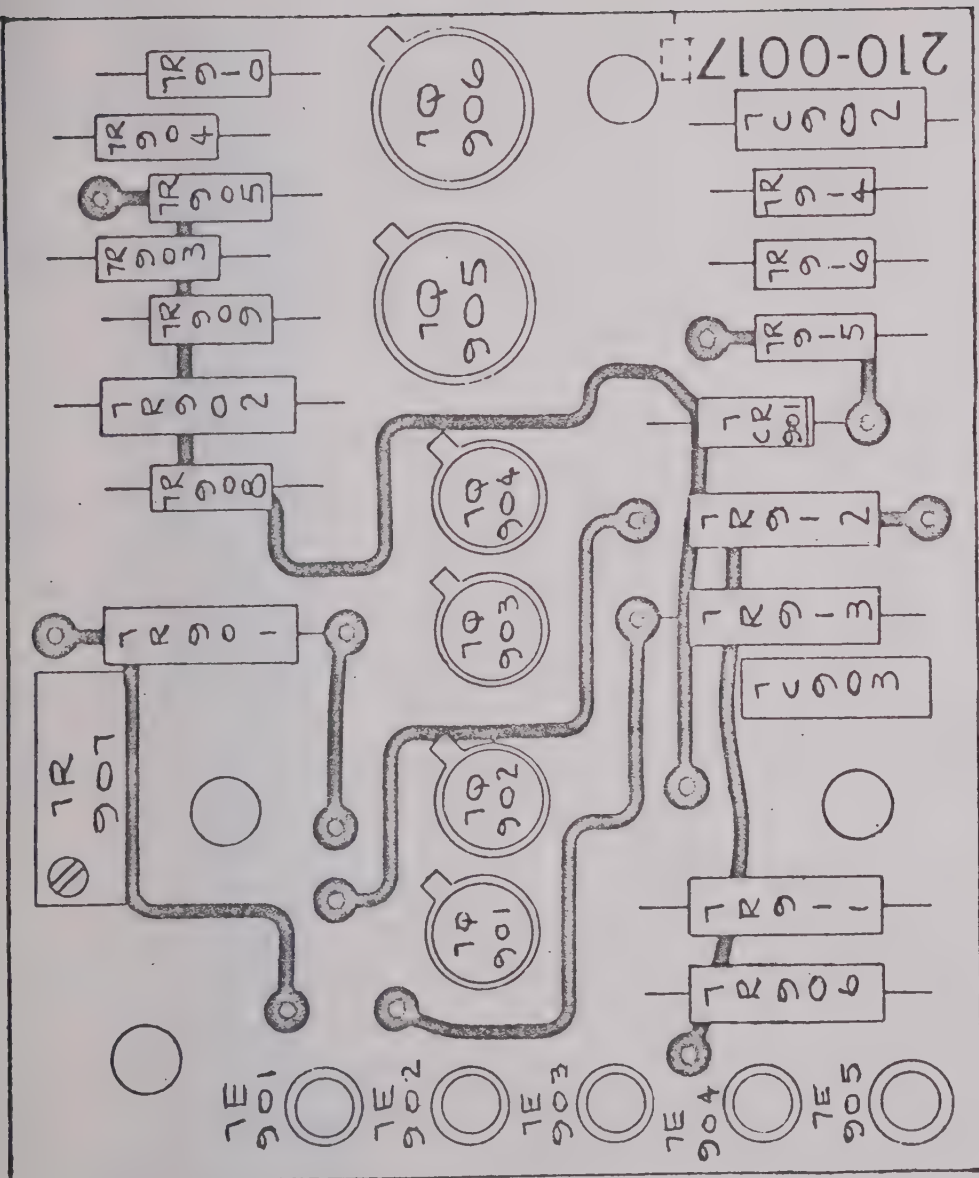
Figure 5-23. Model 210A Oven Printed-Circuit Card,
Component Locations



Notes:

1. All resistor values are in ohms (K=1000) unless otherwise noted.
2. Δ value to be determined at test.
3. ** No. 36 enameled resistance wire, 1Ω/inch (100 inches).
4. EMR Dwg. No. 210-1021.

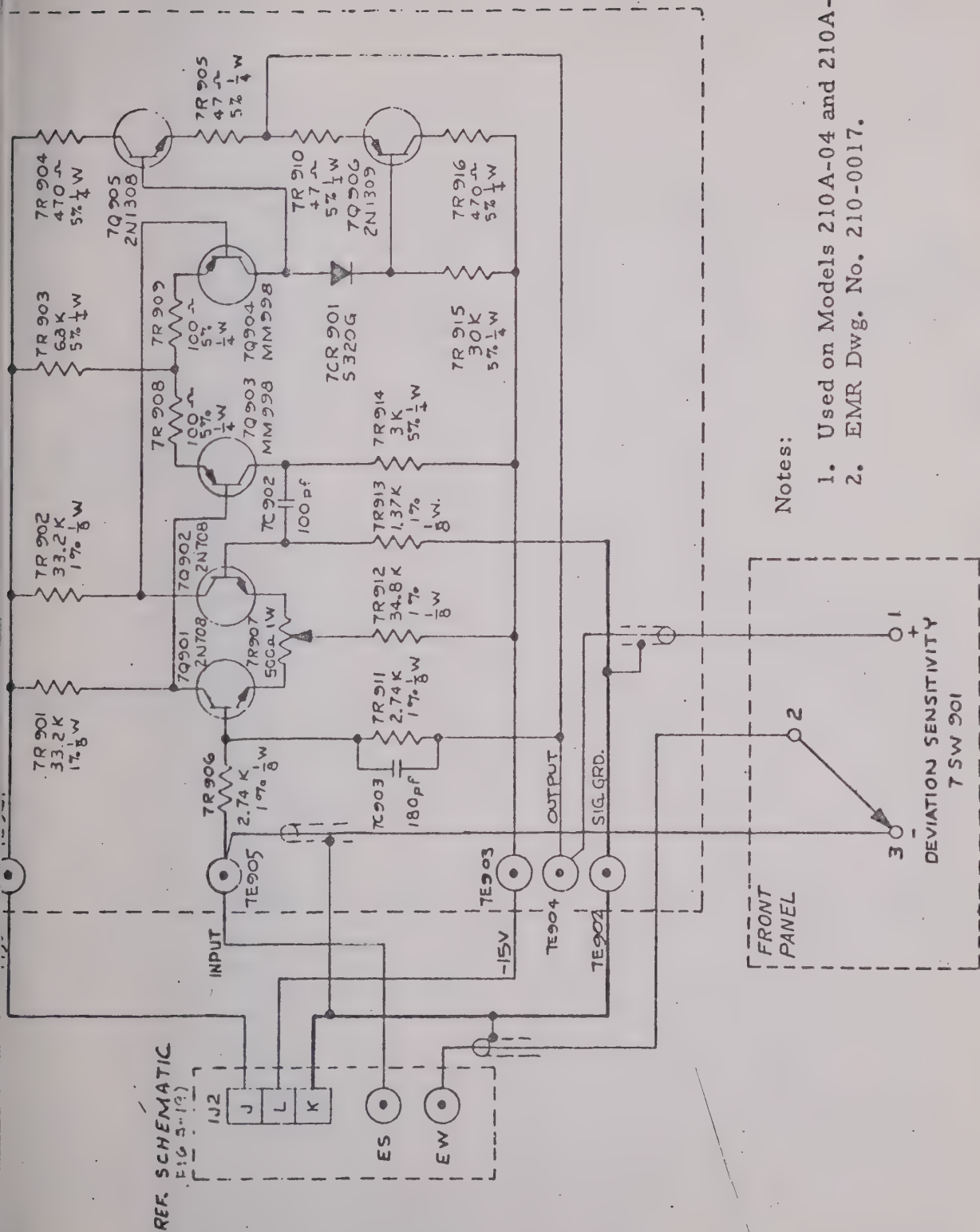
Figure 5-24. Model 210A Oven Card, Schematic Diagram



Notes:

1. Used on Models 210A-04 and 210A-05 only.
2. EMR Dwg. No. 210-0017.

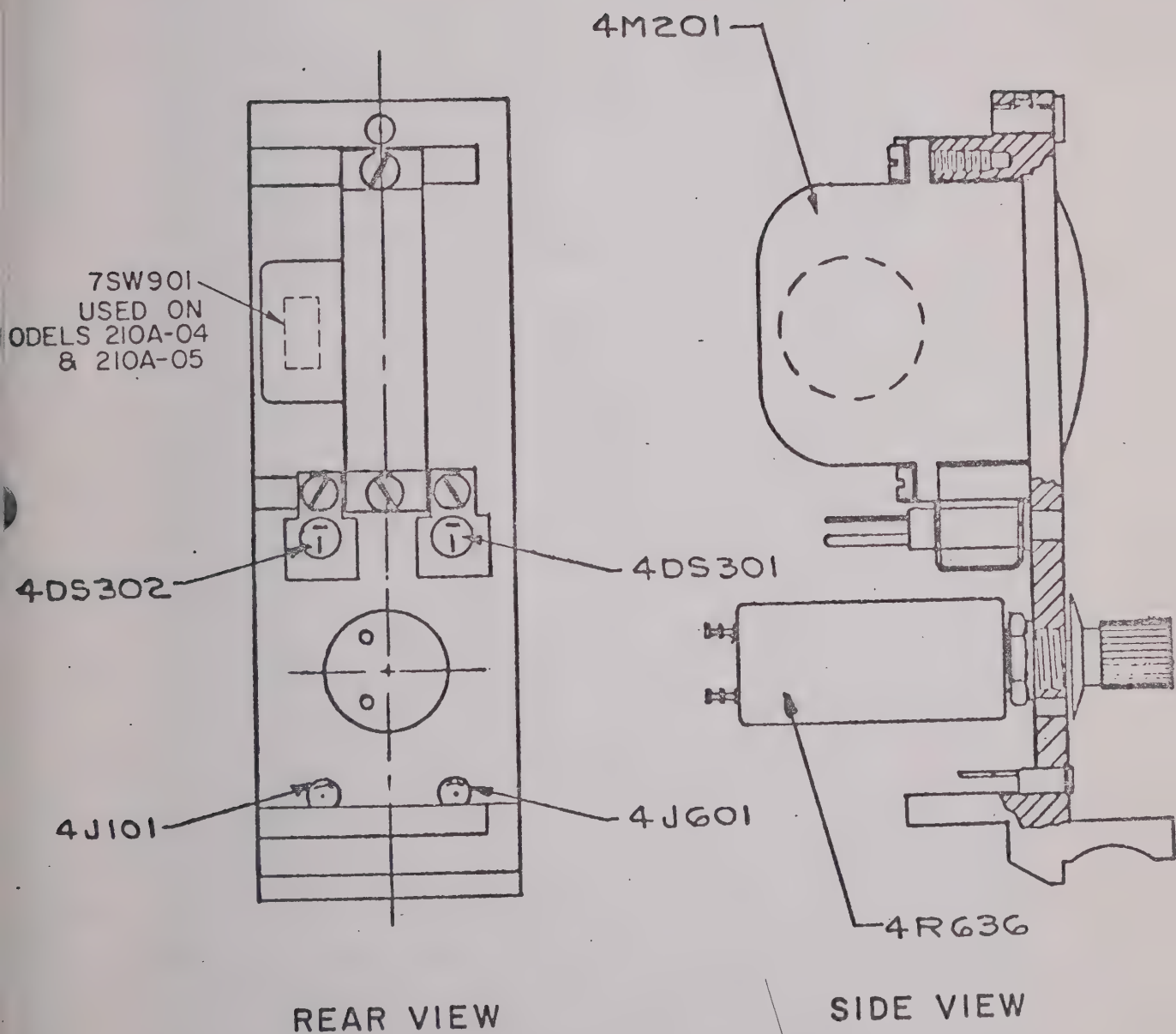
Figure 5-25. Model 210A Inverting Amplifier Printed-Circuit Card, Component Locations



Notes:

1. Used on Models 210A-04 and 210A-05 only.
2. EMR Dwg. No. 210-0017.

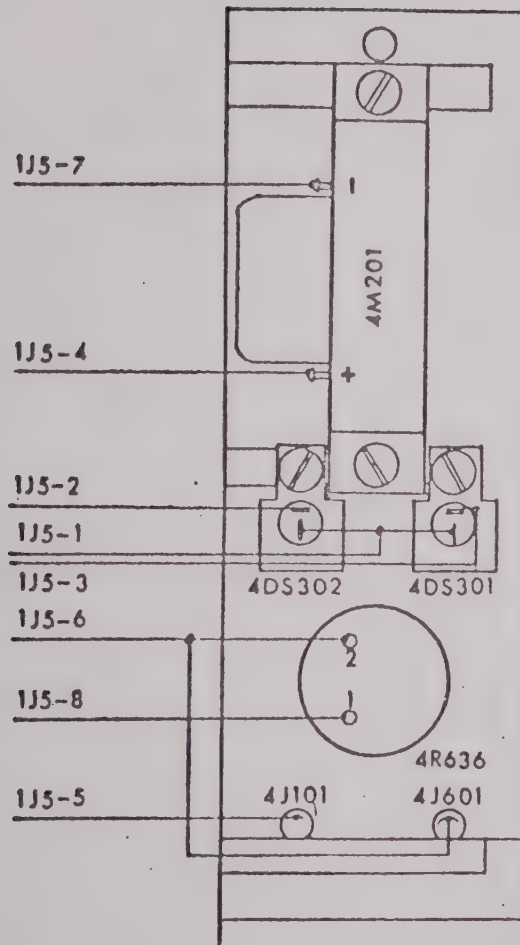
Figure 5-26. Model 210A Inverting Amplifier Printed-Circuit Card, Schematic Diagram



Note:

1. EMR Dwg. No. 210-0014.

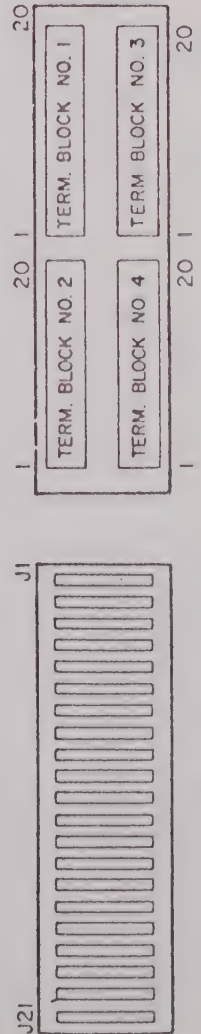
Figure 5-27. Model 210A Front-Panel Assembly, Component Locations



Note:

1. EMR Dwg. No. 210-1014.

Figure 5-28. Model 210A Discriminator Chassis, Front-Panel Wiring

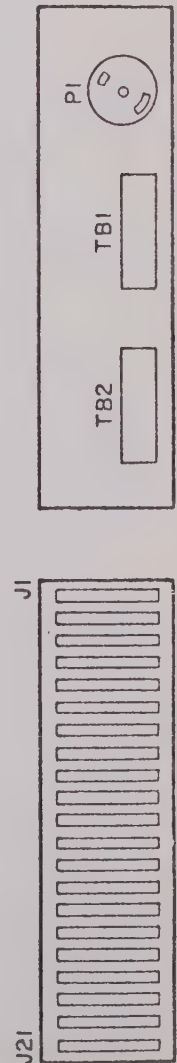
[illegible]

REAR VIEW-TERM. BLOCK CHASSIS

Figure 5-29. Model 222A-01-0999B Rack Adapter, Internal Wiring Schedule

[illegible]

	PI
1	J1Y
2	J1Z
3	J1X GND



REAR VIEW-RACK ADAPTER

REAR VIEW - CONN. CHASSIS

Figure 5-30. Model 222A-02-0999B Rack Adapter, Internal Wiring Schedule

J21	J20	J19	J18	J17	J16	J15	J14	J13	J12	J11	J10	J9	J8	J7	J6	J5	J4	J3	J2	J1
A																J1A				J5A
B																J1B				J5B
C																				
D																				
E																				
F																J1F				J5F
H																				
J																TB3-17				
K																				
L																				
M																				
N																				
P																J1N				J5N
R																				TB3-10
S																TB3-18				
T																				
U																				
V																				
W																J1V				J5V
X																J1W				J5W
Y																J1X				J5X
Z																				PI-1
																				PI-2

TB1	TB2	TB3	TB4
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

PI
1
2
3

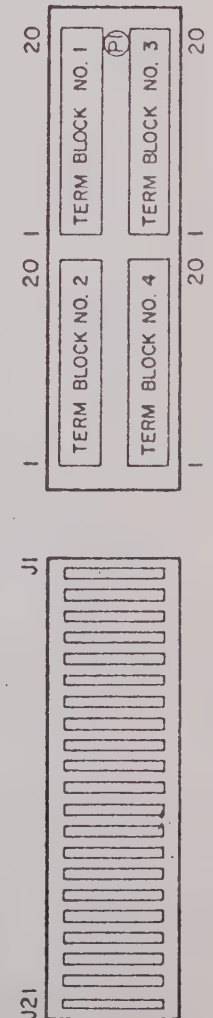


Figure 5-31. Model 222A-03-0999B Rack Adapter, Internal Wiring Schedule

SECTION 6

PARTS LISTS

6.1 GENERAL

This section contains a complete list of replaceable parts for all assemblies of the Model 229 Tunable Channel Selector/Output Filter. Each assembly is listed in a separate table.

Reference designations of the Model 210A components are coded to illustrate circuit usage. The code is as follows:

Component Location Designation

- 1--Main printed-circuit-card assembly; example 1R209
- 2--Secondary printed-circuit-card assembly; example 2C703
- 3--VCO oven assembly
- 4--Front-panel assembly
- 5--Channel selector plug-in (Models 210B or 210T)
- 6--Output filter plug-in (Model 210C)
- 7--Inverting amplifier

Component Circuit Designation

- 100--Limiter; example 5R101
- 200--Phase detector and loop amplifier
- 300--Loss-of-signal and loss-of-lock
- 400--Voltage-controlled oscillator
- 500--VCO oven controller
- 600--Output amplifier
- 700--Chopper amplifier
- 800--Power supply regulators
- 900--Inverting amplifier

Table 6-1. Model 229A Tunable Channel Selector/Output Filter

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
	TUNABLE CHANNEL SELECTOR/OUTPUT	EMR	229-0001
	FILTER ASSEMBLY, MODEL 229A		
	FRONT-PANEL ASSEMBLY (See Table	EMR	229-0002
	6-2 for breakdown)		
	COVER ASSEMBLY, Rear	EMR	229-0006
	CONNECTOR	Amphenol	133-022-21
	COVER ASSEMBLY	EMR	210-1008
	WELDMENT, Top cover	EMR	229-1008

Table 6-2. Model 229A Front-Panel Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	FRONT-PANEL ASSEMBLY (See Table 6-1 for next higher assembly)	EMR	229-0002
	DIAL PLATE ASSEMBLY	EMR	229-0003
	CHANNEL SELECTOR ASSEMBLY	EMR	229-0004
	RESISTOR, Variable (Per EMR Spec 945- 0023)	General Radio	973G8-S1
	LOW-PASS OUTPUT FILTER ASSEMBLY	EMR	229-0005
	RESISTOR, Variable (Per EMR Spec 945- 0024)	General Radio	973G5-S2
	CARD ASSEMBLY, Switching (See Table 6-3 for breakdown)	EMR	229-0009
	CARD ASSEMBLY, Electronic (See Table 6-4 for breakdown)	EMR	229-0010
	CARD ASSEMBLY, Low pass output filter (See Table 6-5 for breakdown)	EMR	229-0011
	CARD ASSEMBLY, Interconnection RESISTOR, Variable	EMR Duncan Elec.	229-1051 3200-836

Table 6-3. Model 229A Switching Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	CARD ASSEMBLY, Switching (See Table 6-1 for next higher assembly)	EMR	229-0009
C1	CAPACITOR, 2000 Pf $\pm 2\%$, 100V	Arco	DM19-20-2G
C2	CAPACITOR, 430 Pf $\pm 2\%$, 100V	Arco	DM15-431G
C3	CAPACITOR, 726 Pf $\pm 1\%$, 100V	Arco	DM15-7260F
C4	CAPACITOR, 2290 Pf $\pm 1\%$, 100V	Arco	DM19-2291F
C5	CAPACITOR, 7260 Pf $\pm 1\%$, 100V	Arco	DM19-7261F
C6	CAPACITOR, 0.0229 μ f $\pm 1\%$, 100V	Arco	DM30-2292F
C7	CAPACITOR, 0.0726 μ f $\pm 1\%$, 200V	Dearborn	DA1P7262F2S1
C8	CAPACITOR, 0.229 μ f $\pm 1\%$, 200V	Dearborn	DA1P2293F2S1
C9	CAPACITOR, 726 Pf $\pm 1\%$, 100V	Arco	DM15-7260F
C10	CAPACITOR, 2290 Pf $\pm 1\%$, 100V	Arco	DM19-2291F
C11	CAPACITOR, 7260 Pf $\pm 1\%$, 100V	Arco	DM19-7261F
C12	CAPACITOR, 0.0229 μ f $\pm 1\%$, 100V	Arco	DM30-2292F
C13	CAPACITOR, 0.0726 μ f $\pm 1\%$, 200V	Dearborn	DA1P7262F2S1
C14	CAPACITOR, 0.229 μ f $\pm 1\%$, 200V	Dearborn	DA1P2293F2S1
C15	CAPACITOR, 0.042 μ f $\pm 2\%$, 200V (Used on Model 229A-01 only)	Dearborn	X1P423G2
C15	CAPACITOR, 100 μ f $\pm 5\%$, 10V (Used on Model 229A-02 only)	Dearborn	
C16	CAPACITOR, 0.126 μ f $\pm 2\%$, 200V	Dearborn	X1P1263G2
C17 and C18	CAPACITOR, 0.82 μ f $\pm 5\%$, 20V (Used on Model 229A-01 only)	Sprague	150D824X5020A2
C17 and C18	CAPACITOR, 0.82 μ f $\pm 5\%$, 10V (Used on Model 229A-02 only)	Sprague	150D824X5020A2
C19	CAPACITOR, 1.5 μ f $\pm 5\%$, 20V	Sprague	150D155X5020A2
C20	CAPACITOR, 8.2 μ f $\pm 5\%$, 20V	Sprague	150D825X5020B2
C21	CAPACITOR, 6.8 μ f $\pm 5\%$, 20V	Sprague	150D685X5020B2
C22	CAPACITOR, 10 μ f $\pm 5\%$, 20V	Sprague	150D106X5020B2
C23	CAPACITOR, 15 μ f $\pm 5\%$, 20V	Sprague	150D156X5020B2
C24	CAPACITOR, 82 μ f $\pm 5\%$, 20V	Sprague	150D826X5020S2
C25 and C26	CAPACITOR, 0.82 μ f $\pm 5\%$, 20V (Used on Model 229A-01 only)	Sprague	150D824X5020A2
C25 and C26	CAPACITOR, 110 μ f $\pm 5\%$, 10V (Used on Model 229A-02 only)	Sprague	
C27	CAPACITOR, 1.5 μ f $\pm 5\%$, 20V	Sprague	150D155X5020A2
C28	CAPACITOR, 6.8 μ f $\pm 5\%$, 20V	Sprague	150D685X5020B2
C29	CAPACITOR, 12 μ f $\pm 5\%$, 20V	Sprague	150D126X5020B2
C30	CAPACITOR, 5.6 μ f $\pm 5\%$, 20V	Sprague	150D565X5020B2
C31	CAPACITOR, 22 μ f $\pm 5\%$, 20V	Sprague	150D226X5020R2
C32	CAPACITOR, 27 μ f $\pm 5\%$, 20V	Sprague	150D276X5020R2
C33	CAPACITOR, 56 μ f $\pm 5\%$, 20V	Sprague	150D566X5020S2
C34 thru C38	CAPACITOR, 120 μ f $\pm 5\%$, 15V	Sprague	150D127X5015S2
C39	CAPACITOR, 750 Pf $\pm 2\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-7500G
C40	CAPACITOR, 3120 Pf $\pm 2\%$, 100V	Arco	DM19-3121G
C41	CAPACITOR, 9370 Pf $\pm 2\%$, 100V	Arco	DM20-9371G
C42	CAPACITOR, 0.0312 μ f $\pm 2\%$, 100V	Arco	DM30-3122G
C43	CAPACITOR, 0.0937 μ f $\pm 2\%$, 200V	Dearborn	X1P9372G2
C44	CAPACITOR, 0.312 μ f $\pm 2\%$, 200V	Dearborn	X1P3123G2
C45	CAPACITOR, Variable, 5.5 to 18 Pf (Used Model 229A-01 only)	Erie	538-007-NPO-5.5-18 Pf
C45	CAPACITOR, 68 μ f $\pm 5\%$, 10V (Used on Model 229A-02 only)	Erie	
C46	CAPACITOR, 6 Pf $\pm 1\%$, 100V	Arco	DM15-6-R0F
C47	CAPACITOR, 80.2 Pf $\pm 1/2\%$, 100V	Arco	DM15-8-0R20E

Table 6-3 (Cont'd.). Model 229A Switching Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
C48	CAPACITOR, 293.2 Pf $\pm 1/2\%$, 100V	Arco	DM15-293R20E
C49	CAPACITOR, 896 Pf $\pm 1/2\%$, 100V	Arco	DM15-8960E
C50	CAPACITOR, 2873 Pf $\pm 1/2\%$, 100V	Arco	DM19-28730E
C51	CAPACITOR, 8978 Pf $\pm 1/2\%$, 100V	Arco	DM20-89780E
C52	CAPACITOR, Variable, 5.5 to 18 Pf (Used on Model 229A-01 only)	Erie	538-007-NPO-5.5-18PF
C52	CAPACITOR, 110 μ f $\pm 5\%$, 10V (Used on Model 229A-02 only)	Erie	
C53	CAPACITOR, 39 Pf $\pm 1\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-390-F
C53	CAPACITOR, 0.0561 μ f $\pm 1\%$, 200V (Used on Model 229A-02 only)	Arco	
C54	CAPACITOR, 166 Pf $\pm 1\%$, 100V	Arco	DM15-1660F
C55	CAPACITOR, 575.4 Pf $\pm 1\%$, 100V	Arco	DM15-575R40F
C56	CAPACITOR, 1757 Pf $\pm 1\%$, 100V	Arco	DM19-17570F
C57	CAPACITOR, 5439 Pf $\pm 1\%$, 100V	Arco	DM19-54390F
C58	CAPACITOR, 0.01756 μ f $\pm 1\%$, 100V	Arco	DM30-17561F
C59	CAPACITOR, 1294 Pf $\pm 1/2\%$, 100V (Used on Model 229A-01 only)	Arco	DM19-12940E
C60	CAPACITOR, 5158 Pf $\pm 1/2\%$, 100V	Arco	DM19-51580E
C61	CAPACITOR, 0.0164 μ f $\pm 1/2\%$, 100V	Arco	DM30-1642E
C62	CAPACITOR, 0.05588 μ f $\pm 1\%$, 200V	Dearborn	X1P55881F2
C63	CAPACITOR, 0.1808 μ f $\pm 1\%$, 200V	Dearborn	X1P18082F2
C64	CAPACITOR, 0.5604 μ f $\pm 1\%$, 200V	Dearborn	X1P56042F2
C65	CAPACITOR, 690.7 Pf $\pm 1\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-690R70F
C66	CAPACITOR, 2525 Pf $\pm 1\%$, 100V	Arco	DM19-25250F
C67	CAPACITOR, 8112 Pf $\pm 1\%$, 100V	Arco	DM19-8-1120F
C68	CAPACITOR, 0.0276 μ f $\pm 1\%$, 100V	Arco	DM30-2762F
C69	CAPACITOR, 0.08849 μ f $\pm 1\%$, 200V	Dearborn	X1P88491F2
C70	CAPACITOR, 0.2759 μ f $\pm 1\%$, 200V	Dearborn	X1P27592F2
C71	CAPACITOR, 1521 Pf $\pm 1/2\%$, 100V (Used on Model 229A-01 only)	Arco	DM19-15210E
C72	CAPACITOR, 5522 Pf $\pm 1/2\%$, 100V	Arco	DM19-55220E
C73	CAPACITOR, 0.01744 μ f $\pm 1/2\%$, 100V	Arco	DM30-17-441E
C74	CAPACITOR, 0.05718 μ f $\pm 1\%$, 200V	Dearborn	X1P57181F2
C75	CAPACITOR, 0.1863 μ f $\pm 1\%$, 200V	Dearborn	X1P18632F2
C76	CAPACITOR, 0.5713 μ f $\pm 1\%$, 200V	Dearborn	X1P57132F2
C77	CAPACITOR, 766.8 Pf $\pm 1\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-766R80F
C78	CAPACITOR, 2493 Pf $\pm 1\%$, 100V	Arco	DM19-24930F
C79	CAPACITOR, 8236 Pf $\pm 1\%$, 100V	Arco	DM20-81360F
C80	CAPACITOR, 0.0265 Pf $\pm 1\%$, 100V	Arco	DM30-2652F
C81	CAPACITOR, 0.0866 μ f $\pm 1\%$, 200V	Dearborn	X1P8662F2
C82	CAPACITOR, 0.2650 μ f $\pm 1\%$, 200V	Dearborn	X1P2653F2
C83	CAPACITOR, Variable, 5.5 to 18 Pf (Used on Model 229A-01 only)	Erie	538-007-NPO-5.5-18PF
C84	CAPACITOR, 15 Pf $\pm 1\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-150F
C84	CAPACITOR, 0.035 Pf $\pm 1\%$, 100V (Used on Model 229A-02 only)	Arco	
C85	CAPACITOR, 101 Pf $\pm 1/2\%$, 100V	Arco	DM15-1010F
C86	CAPACITOR, 354.8 Pf $\pm 1/2\%$, 100V	Arco	DM15-354R80E
C87	CAPACITOR, 1099 Pf $\pm 1/2\%$, 100V	Arco	DM19-10990E

Table 6-3 (Cont'd.). Model 229A Switching Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
C88	CAPACITOR, 3499 Pf $\pm 1/2\%$, 100V	Arco	DM19-3499E
C89	CAPACITOR, 0.01098 μ f $\pm 1/2\%$, 100V	Arco	DM20-10-981E
C90	CAPACITOR, Variable, 5.5 to 18 Pf (Used on Model 229A-01 only)	Erie	538-007-NPO-5.5-18PF
C91	CAPACITOR, 68 Pf $\pm 1\%$, 100V (Used on Model 229A-01 only)	Arco	DM15-680F
C91	CAPACITOR, 0.0958 μ f $\pm 1\%$, 200V (Used on Model 229A-02 only)	Arco	
C92	CAPACITOR, 291 Pf $\pm 1\%$, 100V	Arco	DM15-2910F
C93	CAPACITOR, 918 Pf $\pm 1\%$, 100V	Arco	DM15-9180F
C94	CAPACITOR, 3005 Pf $\pm 1\%$, 100V	Arco	DM19-30050F
C95	CAPACITOR, 8992 Pf $\pm 1\%$, 100V	Arco	DM20-89920F
C96	CAPACITOR, 0.0300 μ f $\pm 1\%$, 100V	Arco	DM30-303F
R1 and R2	RESISTOR, 8.87K $\pm 1\%$, 1/8W	IRC	MEA-T0
R3 and R4	RESISTOR, 2.43K $\pm 1\%$, 1/8W	IRC	MEA-T2
R5	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R6	RESISTOR, 5.62K $\pm 1\%$, 1/8W	IRC	MEA-T2
R7 and R8	RESISTOR, 3.32K $\pm 1\%$, 1/8W	IRC	MEA-T0
R9	RESISTOR, 8.25K $\pm 1\%$, 1/8W	IRC	MEA-T0
R10	RESISTOR, 3.92K $\pm 1\%$, 1/8W	IRC	MEA-T0
R11	RESISTOR, 2.87K $\pm 1\%$, 1/8W	IRC	MEA-T0
R12	RESISTOR, 1.58K $\pm 1\%$, 1/8W	IRC	MEA-T0
R13	RESISTOR, 1K $\pm 1\%$, 1/8W	IRC	MEA-T0
R14	RESISTOR, 825 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R15	RESISTOR, 15.4K $\pm 1\%$, 1/8W	IRC	MEA-T0
R16	RESISTOR, 2.87K $\pm 1\%$, 1/8W	IRC	MEA-T0
R17	RESISTOR, 1.15K $\pm 1\%$, 1/8W	IRC	MEA-T0
R18	RESISTOR, 8.25K $\pm 1\%$, 1/8W	IRC	MEA-T0
R19	RESISTOR, 3.32K $\pm 1\%$, 1/8W	IRC	MEA-T0
R20	RESISTOR, 1.5K $\pm 1\%$, 1/8W	IRC	MEA-T0
R21	RESISTOR, 7.5K $\pm 1\%$, 1/8W	IRC	MEA-T0
R22	RESISTOR, 909 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R23	RESISTOR, 150 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R24	RESISTOR, 3.57K $\pm 1\%$, 1/8W	IRC	MEA-T0
R25	RESISTOR, 909 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R26	RESISTOR, 274 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
S1A thru S1D	SWITCH, Rotary, 3 pole, 2 position	Centralab	991-0008-2
S2A thru S2D	SWITCH, Rotary, 1 pole, 6 position	Centralab	991-0008-1
S3A thru S3D	SWITCH, Rotary, 1 pole, 6 position	Centralab	991-0008-1
J1 thru J3	CONNECTOR	BECON	3705-013
	CARD ASSEMBLY, Plugboard	EMR	229-0013
	CARD, Printed-circuit	EMR	229-1056

Table 6-4. Model 229A Electronic Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	CARD ASSEMBLY, Electronic (See Table 6-1 for next higher assembly)	EMR	229-0010
C1 and C2	CAPACITOR, 100 μ f $\pm$ 20%, 20V	Sprague	150D107X0020S2
C3 thru C10	CAPACITOR, 27 Pf $\pm$ 10%, 100V	Arco	DM15-270K
C11 and C12	CAPACITOR, 3.3 μ f $\pm$ 20%, 15V	Sprague	150D335X0015A2
C13 and C14	CAPACITOR, 100 Pf $\pm$ 10%, 100V	Arco	DM15-101K
C15	CAPACITOR, 0.047 μ f $\pm$ 20%, 200V	Dearborn	X1P473M2
C16 and C17	CAPACITOR, 1.0 μ f $\pm$ 20%, 35V (Used on Model 229A-01 only)	Sprague	150D105X0035A2
C16 and C17	CAPACITOR, 15 μ f $\pm$ 20 $\pm$, 20V (Used on Model 229A-02 only)	Sprague	150D156X0020B2
C18 thru C23	CAPACITOR, 6 Pf $\pm$ 10%, 100V	Arco	DM15-060K
C24	CAPACITOR, 22 μ f $\pm$ 20%, 15V	Sprague	150D226X0015B2
C25	CAPACITOR, 3.3 μ f $\pm$ 20%, 15V	Sprague	150D335X0015A2
C26	CAPACITOR, 22 μ f $\pm$ 20%, 15V	Sprague	150D226X0015B2
C27	CAPACITOR, 3.3 μ f $\pm$ 20%, 15V	Sprague	150D335X0015A2
C28 thru C35	CAPACITOR, 27 Pf $\pm$ 10%, 100V	Arco	DM15-270K
C36 thru C39	CAPACITOR, 6 Pf $\pm$ 10%, 100V	Arco	DM15-060K
C40 and C41	CAPACITOR, 100 μ f $\pm$ 20%, 20V	Sprague	150D107X0020S2
C42	CAPACITOR, 0.047 μ f $\pm$ 20%, 200V (Used on Model 229A-01 only)	Dearborn	MP1P473M2
C42	CAPACITOR, 0.937 μ f $\pm$ 2%, 200V (Used on Model 229A-02 only)	Dearborn	X1P9373G2
C43	CAPACITOR, 1.755 μ f $\pm$ 1%, 200V	Dearborn	LP9A3C17553F
C44	CAPACITOR, 874 μ f $\pm$ 1%, 200V	Dearborn	X1P8743E2
C45	CAPACITOR, 1.863 μ f $\pm$ 1%, 200V	Dearborn	LP9A3C18633F
C46	CAPACITOR, 0.848 μ f $\pm$ 1%, 200V	Dearborn	X1P8483E2
C47	CAPACITOR, 0.047 μ f $\pm$ 20%, 200V	Dearborn	MP1P473M2
CR1 thru CR4	DIODE	Motorola	1N748
CR5 and CR6	DIODE	Motorola	1N754
CR7 thru CR10	DIODE	Motorola	1N751
Q1 thru Q4	TRANSISTOR	Motorola	2N708
Q5	TRANSISTOR	Texas Inst.	2N2188
Q6	TRANSISTOR	Motorola	2N708
Q7 and Q8	TRANSISTOR	Texas Inst.	2N2188
Q9	TRANSISTOR	Motorola	2N708
Q10	TRANSISTOR	Texas Inst.	2N2188
Q11	TRANSISTOR	Motorola	2N708
Q12 thru Q15	TRANSISTOR	Philco	2N2048
Q16 thru Q19	TRANSISTOR	Texas Inst.	2N2188
Q20 thru Q23	TRANSISTOR	Motorola	2N708
Q24 thru Q27	TRANSISTOR	Motorola	2N3250
R1	RESISTOR, 5.6K $\pm$ 5%, 1/4W	Allen Bradley	CB
R2	RESISTOR, 100 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB
R3	RESISTOR, 5.6K $\pm$ 5%, 1/4W	Allen Bradley	CB
R4	RESISTOR, 100 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB
R5	RESISTOR, 5.6K $\pm$ 5%, 1/4W	Allen Bradley	CB
R6	RESISTOR, 100 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB
R7	RESISTOR, 5.6K $\pm$ 5%, 1/4W	Allen Bradley	CB
R8	RESISTOR, 100 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB
R9	RESISTOR, 3K $\pm$ 5%, 1/4W	Allen Bradley	CB
R10	RESISTOR, 130K $\pm$ 5%, 1/4W	Allen Bradley	CB
R11 and R12	RESISTOR, 2.2K $\pm$ 5%, 1/4W	Allen Bradley	CB
R13	RESISTOR, 2.7K $\pm$ 5%, 1/4W	Allen Bradley	CB
R14	RESISTOR, 120K $\pm$ 5%, 1/4W	Allen Bradley	CB
R15	RESISTOR, 130K $\pm$ 5%, 1/4W	Allen Bradley	CB
R16 and R17	RESISTOR, 2.2K $\pm$ 5%, 1/4W	Allen Bradley	CB
R18	RESISTOR, 100K $\pm$ 5%, 1/4W	Allen Bradley	CB

Table 6-4 (Cont'd.). Model 229A Electronic Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
R19	RESISTOR, 2.4K $\pm 5\%$, 1/4W	Allen Bradley	CB
R20 thru R23	RESISTOR, 120 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R24	RESISTOR, 18K $\pm 5\%$, 1/4W	Allen Bradley	CB
R25	RESISTOR, 27K $\pm 5\%$, 1/4W	Allen Bradley	CB
R26	RESISTOR, 7.5K $\pm 5\%$, 1/4W	Allen Bradley	CB
R27	RESISTOR, 18K $\pm 5\%$, 1/4W	Allen Bradley	CB
R28	RESISTOR, 27K $\pm 5\%$, 1/4W	Allen Bradley	CB
R29	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
R30	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R31	RESISTOR, 301 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R32	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R33 and R34	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R35	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R36	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R37	RESISTOR, 1.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R38	RESISTOR, 7.5K $\pm 5\%$, 1/4W	Allen Bradley	CB
R39	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
R40	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R41	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
R42 and R43	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
R44	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
R45	RESISTOR, 820 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R46	RESISTOR, 18K $\pm 5\%$, 1/4W	Allen Bradley	CB
R47	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R48	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R49	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
R50 and R51	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
R52	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
R53	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB
R54	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R55	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB
R56	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R57	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB
R58	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R59	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB
R60	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R61 thru R64	RESISTOR, 120 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
R65	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R66	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R67	RESISTOR, 2K $\pm 1\%$, 1/8W	IRC	MEA-T0
R68	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R69	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R70	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R71	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R72	RESISTOR, 2K $\pm 1\%$, 1/8W	IRC	MEA-T0
R73	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB
R74	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
R75	RESISTOR, 825 Ω $\pm 1\%$, 1/8W	IRC	MEA-T0
R76 thru R78	RESISTOR, 2K $\pm 1\%$, 1/8W	IRC	MEA-T0
R79 thru R82	RESISTOR, 15 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB

Table 6-5. Model 229A Low Pass Output Filter Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	CARD ASSEMBLY, Low Pass Output Filter (See Table 6-1 for next higher assembly)	EMR	229-0011
C1	CAPACITOR, 1240 Pf $\pm 2\%$, 100V	Arco	DM19-1241G
C2	CAPACITOR, 3980 Pf $\pm 2\%$, 100V	Arco	DM19-3981G
C3	CAPACITOR, 0.0124 μ f $\pm 2\%$, 100V	Arco	DM20-1242G
C4	CAPACITOR, 0.0398 μ f $\pm 2\%$, 100V	Dearborn	X1P3982G2
C5	CAPACITOR, 0.124 μ f $\pm 2\%$, 200V	Dearborn	X1P1243G2
C6	CAPACITOR, 0.398 μ f $\pm 2\%$, 200V	Dearborn	X1P3983G2
C7	CAPACITOR, 1.24 μ f $\pm 2\%$, 200V	Dearborn	MP1P1244G2
C8	CAPACITOR, 3.98 μ f $\pm 2\%$, 200V	Dearborn	MP1P3984G2
C9	CAPACITOR, 1890 Pf $\pm 2\%$, 100V	Arco	DM19-1891G
C10	CAPACITOR, 6100 Pf $\pm 2\%$, 100V	Arco	DM19-6120
C11	CAPACITOR, 0.0189 μ f $\pm 2\%$, 100V	Arco	DM30-1892G
C12	CAPACITOR, 0.061 μ f $\pm 2\%$, 200V	Dearborn	X1P613G2
C13	CAPACITOR, 0.189 μ f $\pm 2\%$, 200V	Dearborn	X1P1893G2
C14	CAPACITOR, 0.61 μ f $\pm 2\%$, 200V	Dearborn	X1P614G2
C15	CAPACITOR, 1.89 μ f $\pm 2\%$, 200V	Dearborn	MP1P1894G2
C16	CAPACITOR, 6.1 μ f $\pm 2\%$, 200V	Dearborn	MP1P615G2
C17	CAPACITOR, 280 Pf $\pm 2\%$, 100V	Arco	DM15-281G
C18	CAPACITOR, 964 Pf $\pm 2\%$, 100V	Arco	DM15-9640G
C19	CAPACITOR, 3120 Pf $\pm 2\%$, 100V	Arco	DM19-3121
C20	CAPACITOR, 9640 Pf $\pm 2\%$, 100V	Arco	DM20-9641G
C21	CAPACITOR, 0.312 μ f $\pm 2\%$, 100V	Arco	DM30-3122G
C22	CAPACITOR, 0.094 μ f $\pm 2\%$, 200V	Dearborn	X1P9642G2
C23	CAPACITOR, 0.312 μ f $\pm 2\%$, 200V	Dearborn	X1P3123G2
C24	CAPACITOR, 0.964 μ f $\pm 2\%$, 200V	Dearborn	X1P9643G2
C25	CAPACITOR, 330 Pf $\pm 2\%$, 100V	Arco	DM15-331G
R1	RESISTOR, 5.9K $\pm 1\%$, 1/8W	IRC	MEA-T0
R2	RESISTOR, 1.87K $\pm 1\%$, 1/8W	IRC	MEA-T0
R3	RESISTOR, 4.22K $\pm 1\%$, 1/8W	IRC	MEA-T0
R4	RESISTOR, 3.92K $\pm 1\%$, 1/8W	IRC	MEA-T0
R5	RESISTOR, 4.22K $\pm 1\%$, 1/8W	IRC	MEA-T0
S1A	SWITCH	EMR	991-0008-2
S2A thru S2D	CARD ASSEMBLY, Switch	EMR	229-0012
	SWITCH	Oak Mfg.	991-0012
	CARD, Printed circuit	EMR	229-1052
	WELDMENT, Bottom cover	EMR	229-1010-1
	PANEL, Front	EMR	229-1013-1
	PLANETARY UNIT, Modified 5:1 drive	EMR	229-1024-1
	KNOB, 5:1 drive	EMR	229-1026-1
	KNOB	EMR	229-1001-1
	KNOB	EMR	229-1001-2
	KNOB	EMR	229-1001-3
	KNOB	EMR	229-1001-4
	KNOB	EMR	229-1001-5
	KNOB	EMR	229-1048-1
	PLUG CARD, Chassis	EMR	229-1012-1

Table 6-6. Model 210A Discriminator Chassis

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	DISCRIMINATOR CHASSIS, Model 210A-01	EMR	210-0010
1J2	CONNECTOR and KEY ASSEMBLY	EMR	210-1053
	CONNECTOR	Cinch Mfg.	259-22-30-144
	KEY, Positioning	EMR	210-1052
TP1	TEST JACK, Black	Sealectro	SKT-5BC
TP2	TEST JACK, Red	Sealectro	SKT-5BC
TP3	TEST JACK, White	Sealectro	SKT-5BC
TP4	TEST JACK, Green	Sealectro	SKT-5BC
TP5	TEST JACK, Yellow	Sealectro	SKT-5BC
TP6	TEST JACK, Blue	Sealectro	SKT-5BC
	MAIN CARD ASSEMBLY (See Table 6-7 for breakdown)	EMR	210-0011-1
	SECONDARY CARD ASSEMBLY (See Table 6-8 for breakdown)	EMR	210-0012
	INVERTING AMPLIFIER ASSEMBLY (See Table 6-10 for breakdown)	EMR	210-0017
	FRONT-PANEL ASSEMBLY (See Table 6-11 for breakdown)	EMR	210-0014-2
	SUPPORT, Connector	EMR	210-1011
	SUPPORT, Connector (Used on Serial Nos. 1 through 1752 only)	EMR	210-1038
	COVER ASSEMBLY	EMR	210-1008
	CLIP, Latch	EMR	210-1010
	COVER	EMR	210-1009
	COVER ASSEMBLY	EMR	210-1039
	CLIP, Latch	EMR	210-1010
	COVER	EMR	210-1016

Table 6-7. Model 210A Main Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	MAIN CARD ASSEMBLY (See Table 6-6 for next higher assembly)	EMR	210-0011
1C102	CAPACITOR, 3.3 μ f $\pm$ 20%, 15V	Sprague	150D335X0015A2
1C103 and 1C104	CAPACITOR, 22 μ f $\pm$ 20%, 15V	Sprague	150D226X0015B2
1C105 and 1C106	CAPACITOR, 6.8 μ f $\pm$ 20%, 35V	Sprague	150D685X0035B2
1C108 thru 1C113	CAPACITOR, 22 μ f $\pm$ 20%, 15V	Sprague	150D226X0015B2
1C114	CAPACITOR, 6.8 μ f $\pm$ 20%, 35V	Sprague	150D685X0035B2
1C115	CAPACITOR, 39 Pf $\pm$ 10%, 500V	Arco	DM15-390K
1C116	CAPACITOR, 120 Pf $\pm$ 10%, 500V	Arco	DM15-121K
1C117	CAPACITOR, 39 Pf $\pm$ 10%, 500V	Arco	DM15-390K
1C118	CAPACITOR, 120 Pf $\pm$ 10%, 500V	Arco	DM15-121K
1C201	CAPACITOR, 39 Pf $\pm$ 10%, 500V	Arco	DM15-390K
1C202	CAPACITOR, 27 Pf $\pm$ 10%, 500V	Arco	DM15-270K
1C206 and 1C207	CAPACITOR, 560 Pf $\pm$ 10%, 300V	Arco	DM15-561K
1C210	CAPACITOR, 47 Pf $\pm$ 10%, 500V	Arco	DM15-470K
1C301	CAPACITOR, 3.3 μ f $\pm$ 20%, 15V	Sprague	150D335X0015A2
1C302	CAPACITOR, 6.8 μ f $\pm$ 20%, 35V	Sprague	150D685X0035B2
1C303 and 1C304	CAPACITOR, 22 μ f $\pm$ 20%, 15V	Sprague	150D226X0015B2
1C305 and 1C306	CAPACITOR, 1000 Pf $\pm$ 10%, 100V	Arco	DM15-102K
1C307	CAPACITOR, 0.01 μ f $\pm$ 20%, 200V	Dearborn	X1P103M2
1C401	CAPACITOR, 100 Pf $\pm$ 10%, 500V	Arco	DM15-101K
1C402 and 1C403	CAPACITOR, 27 Pf $\pm$ 10%, 500V	Arco	DM15-270K
1C404	CAPACITOR, 100 Pf $\pm$ 10%, 500V	Arco	DM15-101K
1C405 and 1C406	CAPACITOR, 39 Pf $\pm$ 10%, 500V	Arco	DM15-390K
1CR102 thru 1CR107	DIODE	Fairchild	Per EMR Spec. 951-6008
1CR108 and 1CR109	DIODE	Transitron	1N276
1CR201	DIODE	Transitron	1N276
1CR202	DIODE	Transitron	1N457
1CR301 thru 1CR307	DIODE	Transitron	1N276
1CR401 and 1CR402	DIODE	Transitron	1N276
1CR403	DIODE, Zener, 7.5V $\pm$ 5%, 40.0 Min.	Motorola	1N755A
1CR404 and 1CR405	DIODE	Transitron	1N276
1CR503	DIODE	Transitron	1N645
J3	CONNECTOR	BECON	2805-01
P1	CONNECTOR	Amphenol	133-022-23
1R103	RESISTOR, 3.3K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R104	RESISTOR, 22K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R105	RESISTOR, 4.7K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R106	RESISTOR, 18K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R107	RESISTOR, 3.3K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R109	RESISTOR, 4.7K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R110	RESISTOR, 470 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB
1R111	RESISTOR, 10K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R112	RESISTOR, 22K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R113	RESISTOR, 562 Ω $\pm$ 1%, 1/4W	IRC	MEA-T0
1R114 and 1R115	RESISTOR, 1K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R119	RESISTOR, 100K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R120	RESISTOR, 4.7K $\pm$ 5%, 1/4W	Allen Bradley	CB
1R121	RESISTOR, 470 Ω $\pm$ 5%, 1/4W	Allen Bradley	CB

Table 6-7 (Cont'd.). Model 210A Main Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
1R122	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R123	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R124	RESISTOR, 562 Ω $\pm 1\%$, 1/4W	IRC	MEA-T0
1R126	RESISTOR, 100K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R127	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R128	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R129	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R130	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R131	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R132	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R133	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R134 and 1R135	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R137	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R138	RESISTOR, 2.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R139	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R140	RESISTOR, 820 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R141	RESISTOR, 2.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R142	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R143	RESISTOR, 820 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R201	RESISTOR, 47K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R202	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R203	RESISTOR, 6.81K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R204	RESISTOR, Variable, 500 Ω $\pm 20\%$, 1/4W	Allen Bradley	RP
1R205	RESISTOR, 5.49K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R207	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R208	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R209	RESISTOR, 10K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R210	RESISTOR, 150K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R211	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R212	RESISTOR 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R213	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R214	RESISTOR, 29.4K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R215	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R216	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R217	RESISTOR, 2.87K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R218	RESISTOR, 6.81K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R219	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R220	RESISTOR, 2.87K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R221	RESISTOR, 6.81K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R222	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R223	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R224 and 1R225	RESISTOR, 10K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R236	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R301	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R302	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R303	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R304	RESISTOR, 56K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R305	RESISTOR, 150K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R306	RESISTOR, 39K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R307	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R308	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R309	RESISTOR, 82K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R310 and 1R311	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R312	RESISTOR, 39K $\pm 5\%$, 1/4W	Allen Bradley	CB

Table 6-7 (Cont'd.). Model 210A Main Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
1R313	RESISTOR, 2.87K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R314	RESISTOR, 1.10K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R315	RESISTOR, 100K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R316	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R317	RESISTOR, 22K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R318	RESISTOR, 82K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R319	RESISTOR, Variable, 50K $\pm 20\%$, 1/4W	Allen Bradley	RP
1R320	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R321	RESISTOR, 1.62K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R322	RESISTOR, 2.87K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R323	RESISTOR, 820 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB
1R324 and 1R325	RESISTOR, 150K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R326	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R327	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R328	RESISTOR, 47K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R329	RESISTOR, 100K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R330	RESISTOR, 150K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R401	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R402	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R403	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R404	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R405	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R406	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R407	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R408 and 1R409	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R413	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R414 and 1R415	RESISTOR, 47K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R416	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB
1R419 thru	RESISTOR, 4.64K $\pm 1\%$, 1/4W	IRC	MEA-T0
1R423			
1R428	RESISTOR, 2.26K $\pm 1\%$, 1/4W	IRC	MEA-T2
1R429	RESISTOR, 1.10K $\pm 1\%$, 1/4W	IRC	MEA-T2
1R430	RESISTOR, 8.45K $\pm 1\%$, 1/4W	IRC	MEA-T2
1R431	RESISTOR (Factory adjustment value range from 39K to 1 Meg in 10% EIA values)	Allen Bradley	CB
1R432	RESISTOR, 9.09K $\pm 1\%$, 1/4W	IRC	MEA-T2
1R433	RESISTOR, 27K $\pm 5\%$, 1/4W	Allen Bradley	CB
1Q104 and 1Q105	TRANSISTOR	RCA	2N404
1Q106	TRANSISTOR	RCA	2N1224
1Q107	TRANSISTOR	RCA	2N404
1Q108	TRANSISTOR	RCA	2N1224
1Q109 and 1Q110	TRANSISTOR	RCA	2N404
1Q111	TRANSISTOR	Texas Instr.	2N1304
1Q201	TRANSISTOR	Philco	2N1499A
1Q202	TRANSISTOR	Texas Instr.	2N1304
1Q203 thru	TRANSISTOR	RCA	2N404
1Q210			
1Q211	TRANSISTOR	Texas Instr.	2N1304
1Q301	TRANSISTOR	RCA	2N1224
1Q302 thru	TRANSISTOR	RCA	2N404
1Q305			
1Q306	TRANSISTOR	RCA	2N398A
1Q307	TRANSISTOR	Philco	2N1499A
1Q308	TRANSISTOR	RCA	2N404

Table 6-7 (Cont'd.). Model 210A Main Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
1Q309 1Q401 and 1Q402	TRANSISTOR	RCA	2N398A
	TRANSISTOR	Fairchild	2N708
	TRANSIPAD	Ross Milton	A10044
	TRANSIPAD	Ross Milton	A10028
	INSULATOR, Oven cover	EMR	210-1055
	CARD, Printed circuit	EMR	210-1002-1
	OVEN ASSEMBLY (See Table 6-9 for breakdown)	EMR	210-0015

Table 6-8. Model 210A Secondary Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	SECONDARY CARD ASSEMBLY	EMR	210-0012
2C604	CAPACITOR, 0.33 μ f $\pm$ 20%, 200V	Dearborn	X1P334M2
2C605	CAPACITOR, 100 Pf $\pm$ 10%, 500V	Arco	DM15-101K
2C606	CAPACITOR, 390 Pf $\pm$ 10%, 500V	Arco	DM15-391K
2C607 thru 2C609	CAPACITOR, 0.01 μ f $\pm$ 20%, 200V	Dearborn	X1P103M2
2C610	CAPACITOR, 150 Pf $\pm$ 10%, 500V	Arco	DM15-151K
2C611	CAPACITOR, 0.01 μ f $\pm$ 20%, 200V	Dearborn	X1P103M2
2C612	CAPACITOR, 1000 Pf $\pm$ 10%, 100V	Arco	DM15-102K
2C613	CAPACITOR, 0.1 μ f $\pm$ 20%, 200V	Dearborn	X1P104M2
2C614 and 2C615	CAPACITOR, 22 μ f $\pm$ 20%, 35V, Type 150D	Sprague	226X0035R2
2C616	CAPACITOR, 6.8 μ f $\pm$ 20%, 35V, Type 150D	Sprague	685X0035B2
2C617	CAPACITOR, 150 Pf $\pm$ 10%, 500V	Arco	DM15-151K
2C701	CAPACITOR, 33 Pf $\pm$ 5%, 500V	Arco	DM15-330J
2C702	CAPACITOR, 0.1 μ f $\pm$ 20%, 200V	Dearborn	X1P104M2
2C703 and 2C704	CAPACITOR, 150 Pf $\pm$ 10%, 500V	Arco	DM15-151K
2C705	CAPACITOR, 0.01 μ f $\pm$ 20%, 200V	Dearborn	X1P103M2
2C706	CAPACITOR, 120 μ f $\pm$ 20%, 10V, Type 150D	Sprague	127X0010R2
2C707 and 2C708	CAPACITOR, 6200 Pf $\pm$ 20%, 200V	Dearborn	X1P622M2
2C711 and 2C712	CAPACITOR, 120 μ f $\pm$ 20%, 10V, Type 150D	Sprague	127X0010R2
2C713	CAPACITOR, 47 Pf $\pm$ 10%, 500V	Arco	DM15-470K
2C801 and 2C802	CAPACITOR, 100 μ f $\pm$ 20%, 20V, Type 150D	Sprague	107X0030S2
2CR602	DIODE	Transitron	1N457
2CR603	DIODE	Transitron	1N755A
2CR604	DIODE	Transitron	1N457
2CR605 and 2CR606	DIODE	Transitron	1N276
2CR607 and 2CR608	DIODE	EMR	951
2CR701	DIODE	EMR	951-6008
2CR703 thru 2CR706	DIODE	Transitron	1N276
2CR801 and 2CR802	DIODE	Transitron	1N457
2CR803 and 2CR804	DIODE, Zener, 9.0V $\pm$ 5%, 500 Mw	Transitron	1N936A
2Q601	TRANSISTOR	Texas Inst.	2N929
2Q602 and 2Q603	TRANSISTOR	RCA	2N404
2Q604 and 2Q605	TRANSISTOR	Texas Inst.	2N1304
2Q606	TRANSISTOR	RCA	2N404
2Q607	TRANSISTOR	RCA	2N1224
2Q608	TRANSISTOR	Texas Inst.	2N1304
2Q609	TRANSISTOR	Motorola	2N1011
2Q610	TRANSISTOR	RCA	2N1224
2Q611 and 2Q612	TRANSISTOR	Texas Inst.	2N1304
2Q613	TRANSISTOR	RCA	2N1224
2Q614	TRANSISTOR	Sylvania	2N1228
2Q701	TRANSISTOR	Philco	2N2280
2Q702 thru 2Q705	TRANSISTOR	RCA	2N404
2Q706	TRANSISTOR	Texas Inst.	2N1304
2Q708	TRANSISTOR	RCA	2N404
2Q709	TRANSISTOR	Texas Inst.	2N1304
2Q710 and 2Q711	TRANSISTOR	RCA	2N404

Table 6-8 (Cont'd.). Model 210A Secondary Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
2Q801	TRANSISTOR	Motorola	2N1011
2Q802 thru 2Q804	TRANSISTOR	RCA	2N404
2Q805	TRANSISTOR	Texas Inst.	2N1304
2Q806	TRANSISTOR	RCA	2N404
2Q807	TRANSISTOR	Sylvania	2N1228
2Q808 thru 2Q811	TRANSISTOR	Texas Inst.	2N1304
2Q812	TRANSISTOR	RCA	2N404
2R606	RESISTOR, 22 Meg, $\pm 5\%$, 1/4W	Allen Bradley	CB2265
2R607	RESISTOR, 1.8 Meg $\pm 5\%$, 1/4W	Allen Bradley	CB1855
2R608	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB1535
2R609	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB6825
2R610	RESISTOR, 680 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB6815
2R611	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R612	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB1015
2R613	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
2R614	RESISTOR, 33 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3305
2R615	RESISTOR, 680 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB6815
2R616	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R617	RESISTOR, 100 Ω $\pm 5\%$, 1W	Allen Bradley	GB1015
2R619	RESISTOR, 33 Ω $\pm 3\%$, 10W	Dale	RS10
2R620 and 2R621	RESISTOR, 47K $\pm 5\%$, 1/4W	Allen Bradley	CB4735
2R622	RESISTOR, 560 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB5615
2R623	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R624	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4705
2R625	RESISTOR, 220 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB2215
2R626	RESISTOR, 10 Ω $\pm 5\%$, 2W	Allen Bradley	HB1005
2R627	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R628	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R629	RESISTOR, 180 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB1815
2R630	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4705
2R631	RESISTOR, 220 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB2215
2R633	RESISTOR, 10 Ω $\pm 5\%$, 2W	Allen Bradley	HB1005
2R634	RESISTOR, 33K $\pm 5\%$, 1/4W	Allen Bradley	CB3335
2R635	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R637	RESISTOR, 220 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB2215
2R638	RESISTOR, 680 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB6815
2R639	RESISTOR, 33 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3305
2R640	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R641	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
2R642	RESISTOR, 680 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB6815
2R643	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R644	RESISTOR, 1.5K $\pm 5\%$, 1/4W	Allen Bradley	CB1525
2R645	RESISTOR, 100 Ω $\pm 5\%$, 1W	Allen Bradley	GB1015
2R646	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
2R647	RESISTOR, 33 Ω $\pm 3\%$, 10W	Dale	RS10
2R648	RESISTOR, 100 Ω $\pm 1\%$, 3W	Dale	RS2
2R649	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB2225
2R650 and 2R651	RESISTOR, 1.8K $\pm 5\%$, 1/4W	Allen Bradley	CB1825
2R652	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB2225
2R701	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB1535
2R702	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R703	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R704	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB1535

Table 6-8 (Cont'd.). Model 210A Secondary Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
2R705	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB8225
2R706	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB2225
2R707	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB5625
2R708	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R709	RESISTOR, 47K $\pm 5\%$, 1/4W	Allen Bradley	CB4735
2R710	RESISTOR, 18K $\pm 5\%$, 1/4W	Allen Bradley	CB1835
2R711	RESISTOR, 1.5K $\pm 5\%$, 1/2W	Allen Bradley	EB1525
2R712	RESISTOR, 1.5K $\pm 5\%$, 1/4W	Allen Bradley	CB1525
2R713	RESISTOR, 1.5K $\pm 5\%$, 1/2W	Allen Bradley	EB1525
2R714	RESISTOR, 18K $\pm 5\%$, 1/4W	Allen Bradley	CB1835
2R715 thru 2R718	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
2R719	RESISTOR, 1.8K $\pm 5\%$, 1/4W	Allen Bradley	CB1825
2R720	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB6825
2R721	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB4725
2R722	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB1535
2R723	RESISTOR, 33 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3305
2R724	RESISTOR, 3.9K $\pm 5\%$, 1/4W	Allen Bradley	CB3925
2R725	RESISTOR, 33 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3305
2R726	RESISTOR, 8.2K $\pm 5\%$, 1/4W	Allen Bradley	CB8225
2R728	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB5625
2R729	RESISTOR, 680 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB6815
2R730	RESISTOR, 390 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3915
2R731	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R732	RESISTOR, 500 Ω $\pm 20\%$, 1/4W	Allen Bradley	RP
2R733	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB5625
2R734	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R801	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB3325
2R802	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R803	RESISTOR, 3.9 Ω $\pm 5\%$, 1W	Allen Bradley	CB3925
2R804	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R805	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
2R806	RESISTOR, 909 Ω $\pm 1\%$, 1/4W	IRC	MEA-T2
2R807	RESISTOR, 250 Ω $\pm 20\%$, 1/4W	Allen Bradley	RP
2R808 thru 2R810	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB4725
2R812	RESISTOR, 3.3K $\pm 5\%$, 1/4W	Allen Bradley	CB3325
2R813	RESISTOR, 330 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB3315
2R814	RESISTOR, 3.9 Ω $\pm 5\%$, 1W	Allen Bradley	CB3925
2R815	RESISTOR, 1K $\pm 5\%$, 1/4W	Allen Bradley	CB1025
2R816	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
2R817	RESISTOR, 909 Ω $\pm 1\%$, 1/4W	IRC	MEA-T2
2R818	RESISTOR, 250 Ω $\pm 20\%$, 1/4W	Allen Bradley	RP
2R819 thru 2R821	RESISTOR, 4.7K $\pm 5\%$, 1/4W	Allen Bradley	CB4725
	TRANSIPAD	Milton Ross	A10044
	TRANSIPAD	Milton Ross	A10028
	HEAT SINK, Power Regulator	EMR	210-1017
	PRINTED-CIRCUIT CARD	EMR	210-1003

Table 6-9. Oven Card Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	OVEN ASSEMBLY	EMR	210-0015
3J4	CONNECTOR (Modified)	EMR	210-1022
3Q504	TRANSISTOR	RCA	2N1183A
	OVEN CARD ASSEMBLY	EMR	210-0013
3CR406 thru	DIODE	EMR	951
3CR408			
3CR501 and	DIODE	Transitron	1N645
3CR502			
3Q405 thru	TRANSISTOR	Fairchild	2N708
3Q407			
3Q501 thru	TRANSISTOR	RCA	2N404
3Q503			
3R434	RESISTOR, 1K $\pm 1\%$, 1/10W	IRC	EM
3R435	RESISTOR, 15 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB1505
3R436	RESISTOR, 1K, $\pm 1\%$, 1/10W	IRC	EM
3R437	RESISTOR, 10K $\pm 1\%$, 1/10W	IRC	EM
3R501	RESISTOR, 5.6K $\pm 5\%$, 1/4W	Allen Bradley	CB5625
3R502	RESISTOR, 15K $\pm 5\%$, 1/4W	Allen Bradley	CB1535
3R503	RESISTOR, 2.2K $\pm 5\%$, 1/4W	Allen Bradley	CB2225
3R504	RESISTOR, 10K $\pm 5\%$, 1/4W	Allen Bradley	CB1035
3R505	RESISTOR (Factory adjustment, range 5.6K to 560K) $\pm 5\%$, 1/4W	Allen Bradley	CB
3R506	RESISTOR (Factory adjustment, range 0.909K to 1.62K) $\pm 1\%$, 1/10W	IRC	EM
3R507	RESISTOR, 825 Ω $\pm 1\%$, 1/10W	IRC	EM
3R509	RESISTOR, 464 Ω $\pm 1\%$, 1/10W	IRC	EM
3R510	RESISTOR, 220 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB2215
3R511	RESISTOR, 2.7K $\pm 5\%$, 1/4W	Allen Bradley	CB2725
3RT501	RESISTOR, Thermal, 5K $\pm 20\%$	Victory Eng.	35A18
	PRINTED-CIRCUIT CARD	EMR	210-1004

Table 6-10. Model 210A Inverting Amplifier Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	INVERTING AMPLIFIER CARD ASSEMBLY	EMR	210-0017
7C902	CAPACITOR, 100 Pf $\pm 10\%$, 500V	Arco	DM15-101K
7C903	CAPACITOR, 180 Pf $\pm 10\%$, 500V	Arco	DM15-181K
7CR901	DIODE	Transitron	S320G
7Q901 and 7Q902	TRANSISTOR	Motorola	2N708
7Q903 and 7Q904	TRANSISTOR	Motorola	MM998
7Q905	TRANSISTOR	Texas Inst.	2N1308
7Q906	TRANSISTOR	Texas Inst.	2N1309
7R901 and 7R902	RESISTOR, 33.2K $\pm 1\%$, 1/8W	IRC	MEA-T2
7R903	RESISTOR, 6.8K $\pm 5\%$, 1/4W	Allen Bradley	CB6825
7R904	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
7R905	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4705
7R906	RESISTOR, 2.74K $\pm 1\%$, 1/8W	IRC	MEA-T2
7R907	POTENTIOMETER, 0-500 Ω , 1W	IRC	201-201
7R908 and 7R909	RESISTOR, 100 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB1015
7R910	RESISTOR, 47 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4705
7R911	RESISTOR, 2.74K $\pm 1\%$, 1/8W	IRC	MEA-T2
7R912	RESISTOR, 34.8K $\pm 1\%$, 1/8W	IRC	MEA-T2
7R913	RESISTOR, 1.37K $\pm 1\%$, 1/8W	IRC	MEA-T2
7R914	RESISTOR, 3K $\pm 5\%$, 1/4W	Allen Bradley	CB3025
7R915	RESISTOR, 30K $\pm 5\%$, 1/4W	Allen Bradley	CB3035
7R916	RESISTOR, 470 Ω $\pm 5\%$, 1/4W	Allen Bradley	CB4715
	TRANSIPAD	Milton Ross	A10028
	TRANSIPAD	Delbert Blinn	TP-100
	PRINTED-CIRCUIT CARD	EMR	210-0017

Table 6-11. Front-Panel Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	FRONT-PANEL ASSEMBLY (See Table 6-6 for next higher assembly)	EMR	210-0014
DS1 and DS2	LENS, Indicator	Eldema	CGW-22100-02
J101 and J601	TEST JACK, White	Sealecto	SKT-8
M201	METER, Percent bandedge	EMR	210-1032
4R636	RESISTOR, Variable (Per EMR Spec. 945-0017 or 945-0022)	Duncan Elec.	
7SW901	SWITCH, Toggle (Used on Models 210A-04 and 210A-05 only)	Torsion Bal.	SP-10
	KNOB, Duodial (Used on Models 210A-02 and 210A-05 only)	Berkeley	2606-106-0
	KNOB (Used on Models 210A-01 and 210A-04 only)	EMR	210-1027

Table 6-11. Front Panel Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
DS-1 and DS-2 J101 and J-601 M-201 4R-636	FRONT PANEL ASSEMBLY (See Table 6-7 for next higher assembly)	06141	210-0014-2
	LENS, indicator	03797	CGW-22100-02
	TEST JACK (white)	98291	SKT-8
	METER, percent bandedge	06141	210-1032
	RESISTOR, Variable (Per EMR Spec. 945-0Q17 or 945-0022)	11534	
	SWITCH, toggle	02640	SP-10
	KNOB (modified)	02681	2606-106-0
	KNOB	06141	210-1027

Table 6-11. Front-Panel Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	FRONT-PANEL ASSEMBLY (See Table 6-6 for next higher assembly)	EMR	210-0014
DS1 and DS2	LENS, Indicator	Eldema	CGW-22100-02
J101 and J601	TEST JACK, White	Sealecto	SKT-8
M201	METER, Percent bandedge	EMR	210-1032
4R636	RESISTOR, Variable (Per EMR Spec. 945-0017 or 945-0022)	Duncan Elec.	
7SW901	SWITCH, Toggle (Used on Models 210A-04 and 210A-05 only)	Torsion Bal.	SP-10
	KNOB, Duodial (Used on Models 210A-02 and 210A-05 only)	Berkeley	2606-106-0
	KNOB (Used on Models 210A-01 and 210A-04 only)	EMR	210-1027

Table 6-12. Rack-Adapter Assembly

CIRCUIT SYMBOL NO.	DESCRIPTION	MANUFACTURER	
		NAME	PART NO.
Ref.	RACK-ADAPTER ASSEMBLY (Used on Model 222A-01-0999B only)	EMR	222-0001
	RACK-ADAPTER ASSEMBLY (Used on Model 222A-02-0999B only)	EMR	222-0001
	RACK-ADAPTER ASSEMBLY (Used on Model 222A-03-0999B only)	EMR	222-0001
J1 thru J21	CONNECTOR	Amphenol	143-022-01
	BRACKET ASSEMBLY (Used on Model 222A-01-0999B only)	EMR	222-0013
TB1 thru TB4	TERMINAL BLOCK	Kulka	600-Y-20
	BRACKET	EMR	222-1020-1
	BRACKET ASSEMBLY (Used on Model 222A-03-0999B only)	EMR	222-0014
P1	CONNECTOR, Male	Hubbel	7486
P1	CONNECTOR, Female	Hubbel	7484
TB1 thru TB4	TERMINAL BLOCK	Kulka	600-Y-20
	BRACKET	EMR	222-1020-2
	BRACKET ASSEMBLY (Used on Model 222A-02-0999B only)	EMR	222-0015
P1	CONNECTOR, Male	Hubbel	7486
P1	CONNECTOR, Female	Hubbel	7484
TB1 and TB2	CONNECTOR	AMP	581342-3
	BRACKET	EMR	222-1072-1

Table 6-9 (Cont'd.). Secondary Card Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
2R728	RESISTOR, 5.6 K, $\pm 5\%$, 1/4 W	01121	CB
2R729	RESISTOR, 680 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R730	RESISTOR, 390 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R731	RESISTOR, 1 K, $\pm 5\%$, 1/4 W	01121	CB
2R732	RESISTOR, 500 ohm, $\pm 20\%$, 1/4 W	01121	CB
2R733	RESISTOR, 5.6 K, $\pm 5\%$, 1/4 W	01121	CB
2R734	RESISTOR, 1 K, $\pm 5\%$, 1/4 W	01121	CB
2R801	RESISTOR, 3.3 K, $\pm 5\%$, 1/4 W	01121	CB
2R802	RESISTOR, 330 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R803	RESISTOR, 3.9 ohm, $\pm 5\%$, 1 W	01121	CB
2R804	RESISTOR, 1 K, $\pm 5\%$, 1/4 W	01121	CB
2R805	RESISTOR, 470 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R806	RESISTOR, 909 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R807	RESISTOR, 250 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R808	RESISTOR, 4.7 K, $\pm 5\%$, 1/4 W	01121	CB
thru 2R810			
2R811	RESISTOR, 1.47 K, $\pm 5\%$, 1/4 W	11502	MEA-T2
2R812	RESISTOR, 3.3 K, $\pm 5\%$, 1/4 W	01121	CB
2R814	RESISTOR, 3.9 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R815	RESISTOR, 1 K, $\pm 5\%$, 1/4 W	01121	CB
2R816	RESISTOR, 470 ohm, $\pm 5\%$, 1/4 W	01121	CB
2R817	RESISTOR, 909 ohm, $\pm 1\%$, 1/4 W	11502	MEA-T2
2R818	RESISTOR, 250 ohm, $\pm 2\%$, 1/4 W	01121	CB
2R819 and 2R821	RESISTOR, 4.7 K, $\pm 5\%$, 1/4 W	01121	CB
2R822	RESISTOR, 1.47 K, $\pm 5\%$, 1/4 W	11502	MEA-T2
	TRANSIPAD (Per Mil-M-18794)	07047	A-10044
	TRANSIPAD (Per Mil-M-18794)	07047	A-10028
	HEAT SINK, power regulator	06141	210-1017-1
	CARD, printed-circuit	06141	210-1003-1

Table 6-10. Oven Card Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	OVEN CARD ASSEMBLY (See Table 6-8 for next higher assembly)	06141	210-0013
3CR406 thru 3CR408 3CR501 and 3CR502	DIODE	07263	(Per EMR Spec. No. 951-6008)
3Q405 thru 3Q407 3Q501 thru 3Q503	TRANSISTOR	03877	1N645
3RT501	TRANSISTOR	07263	2N708
3R434	TRANSISTOR	02735	2N404
3R435	RESISTOR, thermal, 5 K, $\pm 20\%$	83186	35A1A
3R436	RESISTOR, 1 K, $\pm 1\%$, 1/10 W	11502	EM-T0
3R437	RESISTOR, 15 ohm, $\pm 5\%$, 1/4 W	01121	CB
3R501	RESISTOR, 1 K, $\pm 1\%$, 1/10 W	11502	EM-T0
3R502	RESISTOR, 10 K, $\pm 1\%$, 1/10 W	11502	EM-T0
3R503	RESISTOR, 5.6 K, $\pm 5\%$, 1/4 W	01121	CB
3R504	RESISTOR, 15 K, $\pm 5\%$, 1/4 W	01121	CB
3R505	RESISTOR, 2.2 K, $\pm 5\%$, 1/4 W	01121	CB
3R506	RESISTOR, 10 K, $\pm 5\%$, 1/4 W	01121	CB
3R507	RESISTOR, (Factory adjusted value range 5.6 K to 560 K in 10% EIA values) $\pm 5\%$, 1/4 W	01121	CB
3R509	RESISTOR (Factory adjusted value range 1.1 K, 1.33 K, or 1.62 K coarse adjustments)	11502	EM-T0
3R510	RESISTOR, 825 ohm, $\pm 1\%$, 1/10 W	11502	EM-T0
3R511	RESISTOR, 464 ohm, $\pm 1\%$, 1/10 W	11502	EM-T0
	RESISTOR, 220 ohm, $\pm 5\%$, 1/4 W	01121	CB
	RESISTOR, 2.7 K, $\pm 1\%$, 1/4 W	01121	CB
	CARD, printed-circuit	06141	210-1004

Table 6-12. Model 223E Power Supply Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	POWER SUPPLY ASSEMBLY, Model 223E-01	06141	223-0026-G1
	POWER SUPPLY ASSEMBLY, Model 223E-02	06141	223-0026-G2
C1 and C2	CAPACITOR, 2900 μ f, $\pm 100\%$, 40 V	56289	32D1267
C3 and C4	CAPACITOR, 25 μ f, $\pm 20\%$, 100 V	56289	112D256C3100J1
P1	CONNECTOR 02	02660	133-022-21
R2 and R3	RESISTOR, 10K, $\pm 5\%$, 1/4 W	01121	CB
R4 and R5	RESISTOR, 22 K, $\pm 5\%$, 1/4 W	01121	CB
T1	TRANSFORMER, power, stepdown (Used on 223-0026-G1 only)	06141	990-0041
T2	TRANSFORMER, power, stepdown (Used on 223-0026-G2 only)	06141	990-0042
	CARD ASSEMBLY, input meter (See Table 6-13 for breakdown)	06141	223-0005
	FRONT PANEL ASSEMBLY (See Table 6-14 for breakdown)	06141	223-0022
	REAR PLATE ASSEMBLY (See Table 6-15 for breakdown)	06141	223-0023
	HEAT SINK ASSEMBLY (See Table 6-16 for breakdown)	06141	223-0024
	CARD ASSEMBLY, connector (See Table 6-17 for breakdown)	06141	223-0025

Table 6-13. Input Meter Card Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	CARD ASSEMBLY, input meter, (See Table 6-12 for next higher assembly)	06141	223-0005
CR101 and CR102	DIODE	07263	FD1031
C105	CAPACITOR, 22 μ f, $\pm 20\%$, 15 V	56289	150D226X0015B2
C106	CAPACITOR, 75 Pf, $\pm 1\%$, 500 V	84171	DM-15-750F
C106A	CAPACITOR, variable, 5-25 Pf, 350 V	15450	557-000-39R
C107	CAPACITOR, 1500 Pf, $\pm 5\%$, 500 V	84171	DM-19-152J
C108 and C109	CAPACITOR, 1 μ f, $\pm 20\%$, 35 V	56289	150D105X0035A2
C110	CAPACITOR, 4700 Pf, $\pm 10\%$, 300 V	84171	DM-19-472K
C111	CAPACITOR, 68 μ f, $\pm 20\%$, 15 V	56289	150D686X0015R2
C112	CAPACITOR, 1 μ f, $\pm 20\%$, 35 V	56289	150D105X0035A2
R105	RESISTOR, 21.5 K, $\pm 1\%$, 1/8 W	11502	MEA-T0
R106	RESISTOR, 8.2 K, $\pm 5\%$, 1/4 W	01121	CB
R107	RESISTOR, 2.2 K, $\pm 5\%$, 1/4 W	01121	CB
R108	RESISTOR, 8.2 K, $\pm 5\%$, 1/4 W	01121	CB
R109	RESISTOR, 11 K, $\pm 1\%$, 1/8 W	11502	MEA-T0
R110	RESISTOR, 3.3 K, $\pm 5\%$, 1/4 W	01121	CB
R111	RESISTOR, 15 K, $\pm 5\%$, 1/4 W	01121	CB
R112	RESISTOR, 10 K, $\pm 5\%$, 1/4 W	01121	CB
R113	RESISTOR, 68 ohm, $\pm$	01121	CB
R114	RESISTOR, 10 K, $\pm 5\%$, 1/4 W	01121	CB
R115	RESISTOR, 2.2 K, $\pm 5\%$, 1/4 W	01121	CB
R116 and R117	RESISTOR, 10 K, $\pm 5\%$, 1/4 W	01121	CB
R118	RESISTOR, 113 ohm, $\pm 1\%$, 1/8 W	11502	MEA-T0
Q101 thru Q105	TRANSISTOR	02735	2N404
	CARD, printed-circuit	06141	224-1014

Table 6-14. Power Supply Front Panel Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	FRONT PANEL ASSEMBLY (See Table 6-12 for next higher assembly)	06141	223-0022
DS	LENS, indicator (Red translucent)	03797	CFW22556-01
J2 thru J4	JACK, tip	15450	SKT8 (WHT)
M1	METER, amplitude	06141	223-1035
S1	SWITCH, toggle	97198	T2106
	CARD ASSEMBLY, switch (See Table 6-18 for breakdown)	06141	223-0006

Table 6-15. Power Supply Rear Plate Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	REAR PLATE ASSEMBLY, (See Table 6-12 for next higher assembly)	06141	223-0023
CR1 thru CR8	DIODE	01295	1N1115
CR9 thru CR12	DIODE	01295	1N646
F1 and F2	FUSE, cartridge, 5A, 125 V	75915	272005
F3	FUSE, cartridge, 1/4 A 125 V	75915	272000
XF1 thru XF3	FUSE HOLDER	75915	282001

Table 6-16. Power Supply Heat Sink Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	HEAT SINK ASSEMBLY (See Table 6-12 for next higher assembly)	06141	223-0024
CR13 and CR14	DIODE	04713	1N3026B
Q1 and Q2	TRANSISTOR	04713	2N1544
R6 and R7	RESISTOR, 390 ohm, $\pm 5\%$, 1 W	01121	GB
	INSULATOR, feed thru	88245	1434
	HEAT SINK	06141	223-1075

Table 6-17. Connector Card Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
R1	CARD ASSEMBLY, connector (See Table 6-12 for next higher assembly)	06141	223-0025
	RESISTOR 390 ohm, $\pm 10\%$, 1 W	01121	GB
	CONNECTOR	06141	223-1048
	CARD, printed-circuit	06141	2231078

Table 6-18. Power Supply Switch Card Assembly, Parts List

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
	CARD ASSEMBLY, switch (See Table 6-14 for next higher assembly)	06141	223-0006
C101	CAPACITOR, 47 Pf, $\pm 1\%$, 500 V	84171	DM-15-470F
C102	CAPACITOR, 350 Pf, $\pm 1\%$, 300 V	84171	DM-15-351F
C103	CAPACITOR, 1350 Pf, $\pm 1\%$, 300 V	84171	DM-19-1351F
C104	CAPACITOR, 4850 Pf, $\pm 1\%$, 300 V	84171	DM-19-4851F
R101	RESISTOR, 14.7 K, $\pm 1\%$, 1/10 W	11502	EM
R102	RESISTOR, 2.1 K, $\pm 1\%$, 1/10 W	11502	EM
R103	RESISTOR, 549 ohm, $\pm 1\%$, 1/10 W	11502	EM
R104	RESISTOR, 150 ohm, $\pm 1\%$, 1/10 W	11502	EM
S101	SWITCH, rotary	81073	45001-6
	CARD, printed-circuit	06141	223-1015

Table 6-19. Rack Adapter Assembly

REF. DESIG.	DESCRIPTION	MFG. CODE NO.	PART NO.
J1 thru J21	RACK ADAPTER ASSEMBLY (Model 222A-01)	06141	222-0001
	RACK ADAPTER ASSEMBLY (Model 222A-02)	06141	222-0001
	RACK ADAPTER ASSEMBLY, (Model 222A-03)	06141	222-0001
	CONNECTOR	02660	143-022-01
TB1, 2, 3, and 4	BRACKET ASSEMBLY (Used only on Model 222A-01)	06141	222-0013
	TERMINAL BLOCK	75382	600-Y-20
	BRACKET	06141	222-1020-1
	BRACKET ASSEMBLY (Used only on Model 222A-03)	06141	222-0014
P1	CONNECTOR, male	74545	7486
P1	CONNECTOR, female	74545	7484
TB1, 2, 3, and 4	TERMINAL BLOCK	75382	600-Y-20
P1 P1 TB1 and TB2	BRACKET	06141	222-1020-2
	BRACKET ASSEMBLY (Used on Model 222A-02)	06141	222-0015
	CONNECTOR, male	06141	7486
	CONNECTOR, female	06141	7484
	CONNECTOR	00779	581342-3
	BRACKET	06141	222-1072-1

